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AGRICULTURAL ENGINEERING

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Developing the Rural Electric Business - - - - - - - - - - - - *C. P. Wagner*

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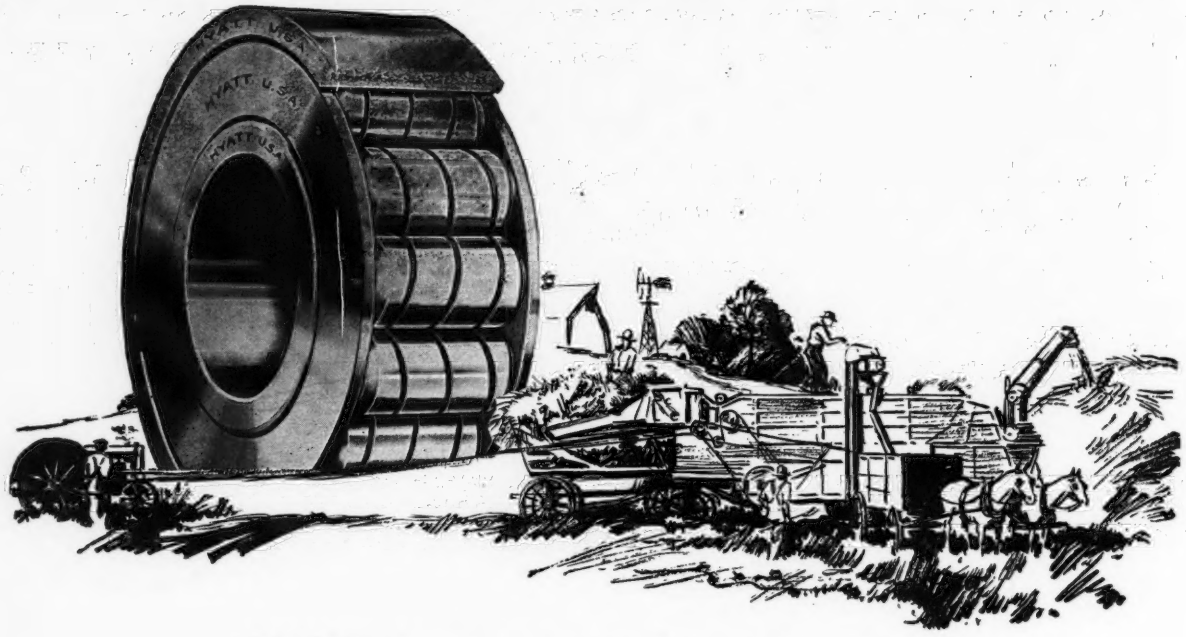

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AGRICULTURAL ENGINEERING

Vol. 9 SEPTEMBER, 1928 No. 9

The Mechanization of Agriculture[1]

By L. J. Fletcher[2]

WHEN engineers consider the problem to be solved by a machine, they think generally of a material of certain characteristics to be moved from one place to another or altered physically. This paper, however, will not attempt to go into the various methods employed by our modern farm machines to accomplish their tasks, but rather it will be devoted mostly to the factors sometimes overlooked when considering the engineering of agriculture.

First, the variables encountered in agriculture influence, to a marked degree, the design of farm machinery. For example, the soil is far from a constant. The draft of a plow may be six times as much in one soil as another. Again, the varying moisture content of the soil may determine whether it may be worked best with one type of tool or another. The abrasive qualities of the soil encountered very materially affect such matters as steel treatments, materials, and enclosures provided to keep the dust out of the bearings. Loose and fast stones in many eastern farming sections furnish a real problem to the designer of tillage machinery. The ability of the soil to provide traction varies greatly and makes necessary extensive studies of lug equipment for wheels, as well as wheel sizes and widths. It was the soft yielding character of the peat and muck soils of the San Joaquin Delta which first prompted Benjamin Holt to develop the track-type tractor.

Variables in topography also present problems to the farm machine designer. Combined harvesters to work satisfactorily on steep hillsides must be provided with leveling devices; plows and other tillage tools are developed so as to be reversible, and special provision must be made to insure the stability of machines on hillsides.

However, the variables of soil and topography may be considered constants in the light of the changes imposed by the weather. Not only will rain cause the soil to vary in many of its characteristics, but it will also materially alter the crop as it reacts to the work of harvesting or threshing machinery. Temperature and humidity variables also have their effect on machines. Variable winds have sometimes been the cause of failures or partial failures of such machines as broadcast seeders, spraying and dusting machinery, hay-drying equipment, and threshing machinery.

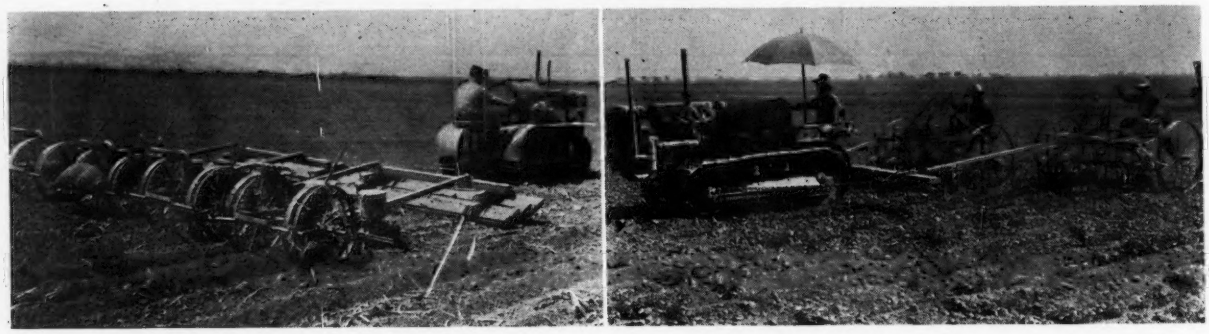
However, in considering the profit derived from agriculture the greatest variable of all is the technical and managerial ability of the farm operator. This is a subject concerning which much could be said. In studies made of profits from farming, numerous cases are discovered where adjacent farms with similar physical conditions have paid one owner a profit while his neighbor suffered a loss, the entire difference being the ability of the operator.

There is another variable in agriculture which may now present a problem, but it also offers one of the most unusual solutions ever offered to any industry. This is the variable of the plant or crop itself. Due largely to the difference in rainfall, wheat grows with a short straw in many western states, while in the middle western and eastern states it produces a rank, heavy straw. On many western farms the straw is a nuisance and its only function is to lift the head of the grain high enough above the ground so that the cutter bar can get underneath. In the East the grain straw is of economic value, and it is desirable to save it for feed and bedding purposes. This is a variable which the manufacturer of combined harvesters must take into consideration. The same may be said of cotton, where in western Texas it is

[1]Contributed by the American Society of Agricultural Engineers for presentation at the summer meeting of the American Society of Mechanical Engineers, at St. Paul, Minn., August, 1928.

[2]Agricultural engineer, supervisor of agricultural sales, Caterpillar Tractor Company. Mem. A.S.A.E.

The variables encountered in agriculture influence, to a marked degree, the design of farm machinery. For example, the soil is far from a constant. The draft of a plow may be six times as much in one soil as another. Again, the varying moisture content of the soil may determine whether it may be worked best with one type of tool or another. The abrasive qualities of the soil encountered very materially affect such matters as steel treatments, materials, and enclosures provided to keep the dust out of the bearings.



(Left) This one-man tractor outfit is planting eight rows of milo maize at one time, doing the work of four men and eight horses. (Right) A tractor outfit cultivating young cotton in California, four rows at a time. It covers 40 acres in a 10-hour day

planted in the bottom of the lister furrow so as to get all the water available, while in the Mississippi delta it is planted on top of a bed or ridge so as to be out of the water. The western Texas cotton grows but a foot or two in height and the bolls may be left on the stem and harvested all at one time in the fall, while in the cotton sections to the east, the plant grows to a considerable height and the cotton must be picked as it matures.

The unusual solution just mentioned has to do with the vast possibilities which the plant breeder can exercise in changing the physical characteristics of the plant so as to enable a more effective use of machinery. For example, there is the development of yolo, a type of grain sorghum grown in California. The varieties of milo and Egyptian corn available up to 1920 did not produce their grain in a fashion uniform enough for machine harvesting. By a process of hybridization and selection there was developed a grain which grew to a uniform height and held its head erect. This made possible the use of a wide variety of machines in the harvesting of the crop. In other words, in agriculture it may be possible to change the characteristics of the plant material worked on to accommodate it to the machine. This may be compared to the possibility of changing the character of steel, so that it would be plastic while cold and yet be capable of hardening without heat.

Economic Factors. Economic considerations enter very strongly into the design of farm equipment. For example, the load factor, that is, the percentage of annual full-load use of all power units employed on farms in the United States, is about 4½ per cent. Manufacturing industries enjoy a load factor of over 14 per cent. Were this efficiency possible in agriculture, the present fifty million primary horsepower could be reduced to less than twenty million. Some well-managed electric utilities are now securing load factors of 50 to 60 per cent.

One of the big problems in agriculture, which has been largely complicated by the emphasis placed on the value of crop diversification, is the large variety of machines needed to produce efficiently several crops on one farm and the relatively small amount of annual use of each machine. For example, on the average corn belt farm, the corn binder is used less than fifty hours a year; and the grain binder, which was developed to displace the tremendous amounts of hand labor involved in cutting and binding grain, is often used but four or five days a year. It is, therefore, easy to see why farm machines are not built with the best type of bearings or with materials which will resist unusual shocks and wear. Well-meaning authors have written articles which point out that a lathe in a machine ship will operate with but little mechanical attention for periods of five to ten thousand hours, while some farm machines will be worn out in five hundred hours. At that the farm machine very likely serves more years than the lathe. The raising of the load factor of its equipment is one of the real problems facing agriculture. The large farm may be the solution.

Another economic consideration is that of quality in farm products. For example, hay of the highest quality may sell for $10 per ton more than hay of the next lower grade. Many people, in studying the handling of hay, consider it just so much material to be moved or lifted. However, a close study of this problem will show that minor changes in the methods employed and the time of their employment are vital factors in producing quality products. There may be an even greater premium placed on quality as a greater industrial utilization of farm products develops.

An economic factor which enters into the quality of the construction of the farm machine is the value of time, or, in other words, the necessity for performing certain operations without delays. For example, the spraying of fruit trees for the control of certain plant diseases or animal pests will frequently be of no value if delayed for as much as one or two days. Hence, the farmer will be more justified in paying for high-quality construction in a spraying machine than in some other piece of equipment where the timeliness of the operation is of much less importance.

Recent Developments in Farm Machinery. It is not possible in this paper to describe or even to mention all of the recent developments in mechanical farm equipment. In tillage machinery the one-way disk has rapidly covered the wheat belt and is finding new markets in the East. A new type of rotary tiller or soil pulverizer is being perfected and put on the market. The rotary hoe has been revived to meet the cultivating needs of the producer of soybeans and corn. There is a general abandoning of the idea of the mulch to conserve moisture and more attention is now given to weed control, especially in preparing better seedbeds and weed eradication immediately after planting while the crop is small.

The control of the corn borer has been due largely to the universal employment of new types of farm machines, such as wide-bottom plows, stubble pulverizers, low-cutting corn binders, and field burners.

Much attention is now being devoted to artificial drying of hay and grain. There are great possibilities in this field for improving the quality of hay, the dependability of the crop, and extending the hay-producing areas.

The windrowing attachment and the windrow and shock pick-up attachments are recent combined-harvester developments which will allow the use of this great labor-saving machine in practically all grain-growing sections.

The mechanical cotton picker is now being used in the South where, with almost uncanny accuracy, it passes through the cotton rows, removing the ripe cotton from the boll and leaving unharmed the green or unopened bolls, the flowers, and the leaves.

A successful sugar-cane harvester has been the object of the expenditure of much time and money. N. C. Storey, of the Southern Sugar Company, Clewiston, Fla., has recently developed a machine which promises a mechanical solution to this problem of cutting, stripping, and topping cane.

There is also a decided tendency toward the combining of several farm operations into one. This is mainly due to the change from the horse to the tractor, where the tractor has ample power to pull several tillage tools or combine them with planting operations. Plows and harrows are being attached to harvesting machines so as to kill the weeds immediately after the harvest and thus conserve moisture for the next crop. General-purpose tractors designed to plant and cultivate two, three, and four rows at a time are now on the market. Potato diggers are built to dig two rows at a

time, their mechanism being operated through a power take-off from the tractor engine. The South is beginning to realize her many natural advantages of soil, moisture, and growing season and is adopting machine methods of production. Near Leesburg, Ga., a 500-acre field of peanuts has been handled entirely up to harvest by two men and a tractor; the work including the initial tillage, weeding, planting, and cultivating five rows at a time, and later the same equipment will be used to dig the peanuts. Several new methods of harvesting will be tried out. This work is being supervised by J. I. Davis, the local county agricultural agent.

Present Trend of Development. It is quite evident that until the last few years the motive behind the development of farm machinery was to save labor. In fact, modern farm machinery is usually spoken of as "labor-saving" farm machinery. Tillage tools for use with animals were developed first, thus relieving the early farmer of the task requiring the most in physical exertion. Later harvesting machinery was developed and, after that, planting machinery. The present trend in farm machinery, however, is somewhat away from the labor-saving factor and is beginning to consider profit-making possibilities. In other words, present machines must answer the question, Does it do the work cheaper for the same quality, or does it produce a better quality at the same cost? As an example of this new method of approach, we have potato pickers which are attached behind a digger. Men riding on these pickers remove stones, clods, and other foreign material, while a man riding on the rear of the machine aids in the sacking operation. Here, as in other types of new machines, the man is used in places where judgment is required, while the machine relieves him of transporting himself or the product and removes from him, as far as possible, all unnecessary effort.

Farmers are today trying new methods as never before in the history of agriculture. This is largely due to the combined result of the educational work conducted so effectively by state and federal agricultural extension workers and the well-directed farm press. The continuous airing of the "farm problem" by politicians is tending also to make the farming industry realize that something should be done and it is quite evident that it will be largely up to the farmer to do it. The rapid increase in the use of the combined harvester east of the Rockies is an example of the present tendency to adopt new methods quickly. Thirty years ago thousands of eastern wheat farmers knew of the successful use of the combine on the Pacific Coast. The belief that it would not handle the grain produced under more humid conditions together with the reluctance to change methods prevented, for many years, the introduction of this most profitable machine.

Because of this increased confidence in new methods it is most important that designers of farm machines acquaint themselves with all of the requirements that the machine must meet.

There is need for more basic data on which to base the design of machinery. This is particularly true of tillage machinery. State and federal agricultural experiment stations now have under way many projects which, when completed, will furnish valuable data and information to the designer of farm machines.

It is always somewhat dangerous to make predictions, particularly in writing, for they have a habit of bobbing up in later years. However, there are certain conditions existing today which are bound to influence the character of farming and thus the character of mechanical farm equipment.

The complication of the problems facing agriculture is increasing very rapidly. It is quite evident that trained management pays in agriculture and that there is now need for the specialist in crop and animal production, disease control, management of power and machinery, and marketing.

The agricultural colleges are adding annually to this group of trained men; but the average farm of today does not offer a sufficient inducement to these graduates as compared to other outlets for their abilities.

The immigration policy, which keeps out of the country large numbers of people who would be content to use hand equipment in agricultural production, is making necessary the use of machines for multiplying the effort of one man.

This country does not labor under a caste or peonage system in which farm laborers are considered inferior to the professional man or manufacturer. Here agriculture is a respected occupation and there is nothing to prevent its developing further as a great industry with able management and well-paid workers.

Our tariff policy is clearly one of protecting our own industries, and it seems very probable that some way will be found to apply this principle to agricultural production.

One of the present problems of agriculture is that of paying too much for credit. In general, money at comparatively low interest rates is available in this country for safe investments. If the present high credit charges are justified, how can the risk be removed so that agriculture may enjoy low money rates comparable to other industries?

There is also being gradually developed here and there the partial manufacturing of agricultural products on the farm. In some ways this will help utilize existing power and machinery equipment and thus raise the load factor. It will offer much more continuous employment for labor and thus tend to do away with the seasonal nature of some agricultural employment. One of the major problems in connection with manufacturing on the farm is the matter of standardization of the product so that it may be marketed or utilized by urban industries for completing the manufacturing process.

Studies made recently tend to show that in spite of a decreasing farm population there is a considerable increase in the amount of crops produced; thus it would seem that by producing a surplus and thus lowering prices, agriculture is suffering from its own efficiency.

A peculiar paradox existing today is that as the nation becomes more prosperous less food is actually consumed. The machine has relieved us from being the producers of energy; we are now the directors of power; it takes less meat and potatoes to handle the throttle than the pickax and shovel.

One of the bright spots in this situation, however, is the rapid tendency to develop "non-stomach" uses for agricultural products, that is, such materials as wallboard from sugar cane bagasse or corn stalks; rayon from cellulose derived from a wide variety of plant material; oils from soybeans, used in the manufacture of paints and varnishes. In the experimental laboratory many synthetic products have been made from corn cobs and corn stalks which tend to point the way toward future economic developments.

(Left) For thirty years farmers east of the Rockies knew of the successful use of the combine on the Pacific Coast, and now that its use in the more humid areas has proven practical, it is coming into widespread use. (Right) An example of combining farming operations. This outfit is making a very good seedbed in one operation

Mechanical farm equipment itself has undergone marked changes in recent years. The tractor has become a dependable economical source of energy, and farm machines well adapted to tractor operation are increasing in number each year. The tools for a different agriculture are being developed today.

Many people will say that the factors which have been mentioned point the way toward corporation or large farming. However, a study of the census will show that there is also a large increase in the number of very small farms. Many of these are located near cities and are mainly the residences of city workers who desire to live in rural surroundings. Other small farms are used to produce crops which pay a large return for more intensive cultivation. Another reason for these small farms is the enthusiastic real estate man who secures a parcel of land near a city and divides it up into five and ten-acre farms, advertising vigorously the advantages of rural life and its attendant freedom. Many of these small farmers have learned differently. There is even now beginning to be evident a lessening in the number of the middle-sized farm.

My purpose in presenting these factors, which are bound to influence the development of agricultural machinery, is not to prove a prediction, but rather to allow the reader to predict for himself. If the large farm does prove to be the way out, then farm machinery will undoubtedly undergo many changes. With better load factors, many machines may be built of higher quality and in larger sizes. Added impetus will be given to the changing of the character of farm crops so they may be more economically handled by machines. It should be possible to determine the relative value of all crops capable of production in the United States on the basis of their use for food, shelter, or clothing for domestic as well as export consumption. Each of these crops could be studied from the standpoint of production by modern American machinery methods. If it were clearly shown that hand cultural methods were absolutely necessary for the production of a certain crop, then why should not this crop be raised by the nation which uses hands rather than heads? We could then exchange for it crops produced here or go without, or produce a synthetic substitute. After all, does not this problem reduce itself to the producing of more units of food, shelter, or clothing at a lower expenditure of labor and money so that an ample profit may be returned to the manufacturer—that is, the farmer?

Steel Roof Blankets Fire in Severe Government Tests

THAT a galvanized sheet steel roof of the type usually found on farm buildings will serve somewhat as a blanket on relatively severe fires and will effectually reduce the hazard from flying sparks and burning embers was indicated in connection with a fire test recently conducted by the U. S. Bureau of Standards. The test was conducted for the two-fold purpose of (1) determining just how much punishment various types of steel safes could withstand and still preserve the valuable records which they might contain, and (2) ascertaining the extent to which a steel roof on one farm building would confine an internal fire and prevent the transmission of flames to other nearby structures by eliminating the danger arising from flying sparks and fire brands.

A five-story building, 30 ft. wide and 75 ft. long stood in Washington about midway between the Capitol and the White House. The building, about 21 years old and for years used as a seed and feed store, was of open-joisted construction. The walls were of brick. The floors were wood and joists were of timber supported by heavy wood columns. Owing to a desire on the part of Congress to further beautify the capitol city, it was decided that the building must come down to make way for more imposing structures.

Authority was granted the U. S. Bureau of Standards to use the building for this test. Various types of safes, thirty-two in number, were donated by safe manufacturers interested in learning just how much punishment their particular product could stand.

Only one thing might make the conduct of the test dangerous under certain weather conditions. With a wind blowing toward surrounding buildings, they might be endangered by the hot blast from the fire or by flying sparks or fire brands.

The old roof of the building to be burned was of such composition that it would quickly catch fire in such a test. Under the terrific heat generated by the burning of the old dry lumber, purposely piled on floors below, this roof would soon be burned through, thus providing a chimney-like avenue of escape for any sparks or fire brands that might be born in the inferno underneath.

Because of this condition the U. S. Bureau of Standards invited the Sheet Steel Trade Extension Committee to cooperate in the test by placing a steel roof over the old roof. Double standing seam galvanized steel roll roofing was used.

Following, in part, are the observations of the Bureau of Standards on the test:

"The framing carrying the elevator penthouse at the front of the building fell at 22 min. after the fire was started, carrying a portion of the roof with it. Further collapse of roof supports in this part of the building occurred during the next 5 min., leaving the front part of the metal roof unsupported. At 28 min. portions of the front wall fell, and between 36 to 39 min. there was a collapse of the upper portions of the sidewalls. This would, of course, remove all support for any roofing.

"However, particularly with masonry walled buildings, the danger from hot blasts and brands is largely over when this stage is reached. The period of protection of the metal roof during this particular fire extended up to 30 min. after the fire started, which represents a portion of the most intense period of the fire. The metal roof for this time undoubtedly helped to prevent a chimney effect, compelling the flames and hot gases to escape mainly through the front and rear of the buildings.

"We greatly appreciate the courtesy shown in placing the steel roof on the building as a safeguard against a potential hazard that fortunately did not develop, under conditions present during the test, to such extent as was apprehended."

A two-story building adjoining the five-story structure also was included in the test. This building had an old tin roof on it, and although the fire produced openings in this roof at about the same time as the other building no flying fire brands escaped from it before it was buried by the collapse of the adjacent wall of the five-story building at 39 min. after the start of the fire.

John A. Pierpoint, past-president of the National Association of Sheet Metal Contractors, who laid the steel roof and closely observed the test, reports as follows concerning the behavior of the roof:

"The roof rafters and old composition roof were soon burned away, leaving the sheet steel roof suspended over the fire. The steel roof continued to wave up and down over the fire until a part of the wall at the southeast corner near the elevator shaft gave way.

"All of the floors at the front had been burned out and had fallen before this. The fire seemed to burn from the front toward the back, but the steel roof was still waving up and down after everything else had burned up.

"I only wish every farmer in the country could have seen how the sheet steel roof continued to wave up and down, even though it was red hot from the terrific heat below, and at the same time preventing all burning embers from going above the line of the roof. As a fire blanket or retardant, I feel that the sheet steel roof was a complete success. The test shows that the double-locked cross seams and standing grooved seam will hold together until the metal gets to near the melting point."

The Unit Space Method of Barn Planning

By Deane G. Carter[1]

A SPACE unit for farm barns has been developed at the Arkansas Agricultural Experiment Station as a result of a study of plan requirements and plan service during the past four years. The objectives were:

1. To develop, if possible, a space unit consistent with barn requirements that would afford maximum adaptability to individual needs.

2. To develop, by application of the space unit, a barn plan to meet the wide range of conditions imposed by the variations in kind and number of animals, amount of storage, number of pens, size of farm and system of farming.

3. To simplify the problem of plan service, and reduce the work of barn planning on the part of agricultural experiment stations and other plan service agencies; to furnish a flexible or adaptable method of planning in order that extension agencies might offer a more complete and definite service to patrons.

It is obvious that personal tastes, size of farm, method of farming, number of animals, and, incidentally, the farm barn cannot be standardized. Therefore, any adopted standard of space must be interchangeable as to use, and flexible as to amount and kind of housing.

This discussion is concerned only with a standard unit of space in the barn, rather than with the entire structure. The adoption of the space unit has resulted in more flexibility rather than less.

The "unit space" discussed in the following paragraphs comes closely within the limits of recognized good practice. It is specifically intended to provide plan assistance in the great majority of cases where the needs are not special, and where a designer's service is not available. However, it is applicable to dairy barns or horse barns as well.

Space Requirements of Farm Animals and Storage. Leaving out of consideration highly specialized conditions, it is possible to designate within close limits the usual space and volume requirements in the farm barn. It was not within the scope of this study to develop new requirements of barn space. However, in the development of the unit, the dimensions were based upon the sizes, spaces, and areas in common use.

It is almost universal among designers of farm buildings, to accept the following figures for the crosswise dimensions in the farm barn:

Central driveway	7 ft. 8 in. to 8 ft. 0 in.
Central feed alley	4 ft. 6 in. to 6 ft. 0 in.
Central litter alley	6 ft. 0 in.
Side feed alley	3 ft. 6 in. to 5 ft. 0 in.
Side litter alley	4 ft. 0 in. to 5 ft. 6 in.
Cow stall gutter	16 in. to 18 in.
Standing platform	4 ft. 6 in. to 5 ft. 0 in.
Stanchion curb	4 in. to 6 in.
Feeding manger	2 ft. 0 in. to 3 ft. 0 in.
Foundation wall at floor line	8 in. to 12 in.
Horse feed manger	2 ft. 0 in.
Horse stall, behind manger	7 ft. 0 in.
Feed alley for horses	3 ft. 0 in. (minimum)
Alley behind horses	5 ft. 6 in. (minimum)
Calf pen with manger	8 ft. 6 in.
Cow pen	8 ft. 0 in.
Bull pen	9 ft. 0 in.
Feed and store rooms	variable

Standard plans for barns with a two-row arrangement vary from 32 to 38 ft., with 36 ft. as the most common dimension. Thirty-four feet appears to be second in number of times used. It is obvious that the crosswise dimensions, as given in the foregoing list can be developed in the 34-ft. barn. Because minimum satisfactory requirements were sought, 34 ft. was taken as the proposed crosswise unit. This width allows for some choice in the selection of stalls, alleys, gutters, mangers, and other items making up the total dimension.

Lengthwise Measurements. It is more difficult to find a satisfactory unit for the lengthwise measurements in the general barn. The only limitation for pens is the minimum for animal comfort, safety and convenience. Feed and store rooms are designated by capacity, and any desired dimensions may be used. Horse stalls for single animals are universally made 5 ft. wide; cross alleys and stairs to loft vary from 3 to 4 ft. Dairy stalls are designated as 3 ft. 6 in. wide in a majority of plans. In practice however, a wide range in size of animals occupying 3 ft. 6 in. stalls is noted, and in actual buildings cows are placed in stalls from 3 to 4 ft. wide. The University of Arkansas Holstein herd is housed satisfactorily in stalls 3 ft. 3 in. wide. A typical plan may therefore include lengthwise dimensions of 3 ft. 6 in. cow stalls, 3 ft. 6 in. cross alleys, 3 ft. stairs, 5 ft. horse stalls, 10 ft. horse box stalls, 6 ft. harness room, 7 ft. calf pens, 8 ft. cow pens, 9 ft. bull pens, and feed rooms which vary from 6 to 12 ft. in width.

The Development of the Unit Space. Preliminary study

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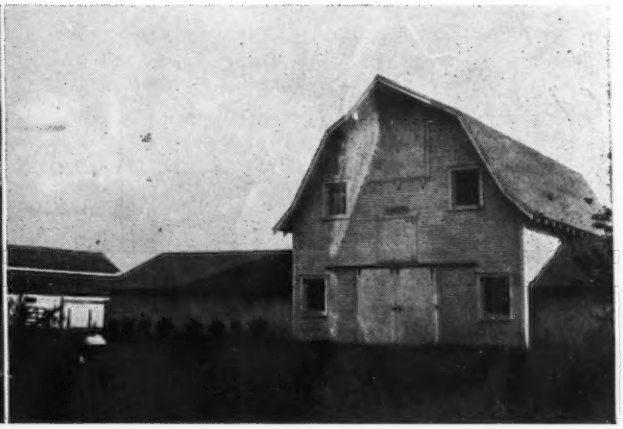


Fig. 4. (Left) New 100 ft. dairy wing just completed at the University of Arkansas. Thirty units long, providing for 30 cows, 4 calf pens, 3 cow pens, and feed room. Fig. 7. (Right) A small barn, originally built as a sheep barn, but identical in size and construction with the small unit space barn

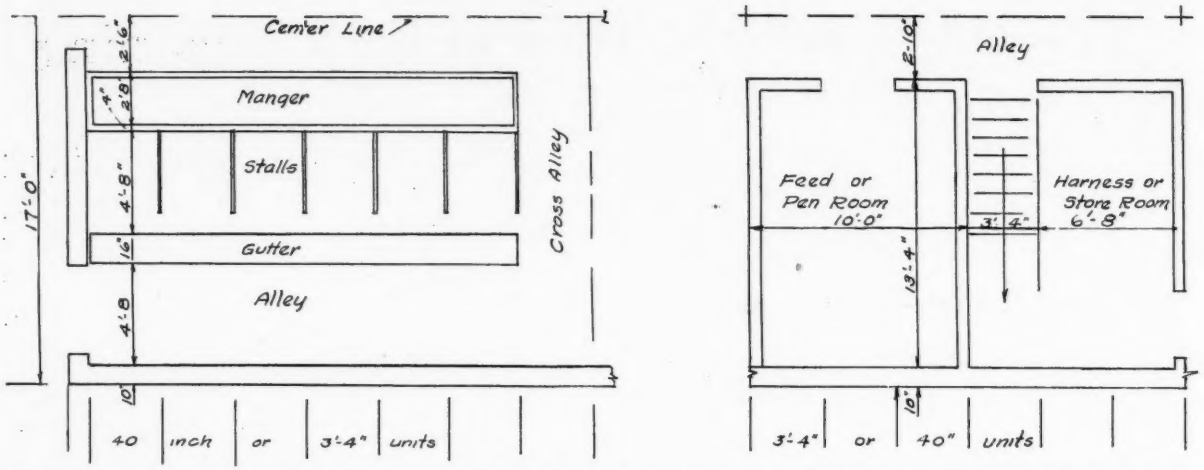


Fig. 1. (Left) A typical plan of one-half the width of the dairy barn, showing the application of the unit space to cow stalls, cross alley and end wall. The opposite side would be symmetrical. Using typical construction this plan may be increased or decreased to meet individual needs. Fig. 2. (Right) Pen section of typical barn. Each pen, feed room, box stall or stair and storage space is three units wide and 13 ft. 4 in. long. The space may be equipped for animals or storage; or 3 cow stalls or 2 horse stalls may occupy this area

indicated that a distance of 10 ft. would prove satisfactory for a number of items in the plan. Two horse stalls, a horse box stall, feed room, or average size animal pen may be 10 ft. in one dimension. However, the standard dairy stall space requires 10 ft. 6 in. for three stalls. The change to a 3 ft. 4 in. stall was adopted as coming within the minimum requirements, permitting three stalls in 10 ft.

The selection of a 10-ft. lengthwise unit did not, however, make provision for the end walls, stairs, cross alley, harness room, or small feed room.

It will be noted that a 10-in. foundation wall is one-fourth the width of a 3 ft. 4 in. dairy stall. Cross alleys and stairs just the width of a dairy cow stall are satisfactory. Two widths of 3 ft. 4 in. proves satisfactory for a harness room, small calf pen, feed room, or store room.

These factors led to the selection of the dairy stall width, 3 ft. 4 in., or one-third of 10 ft. as the "space unit." In a typical general plan, the full space unit becomes "Three feet four by thirty-four." For one-half the barn the unit is 3 ft. 4 in. by 17 ft.

Lengthwise Units. In setting up the unit spaces common in the farm barn, the following have been tentatively adopted:

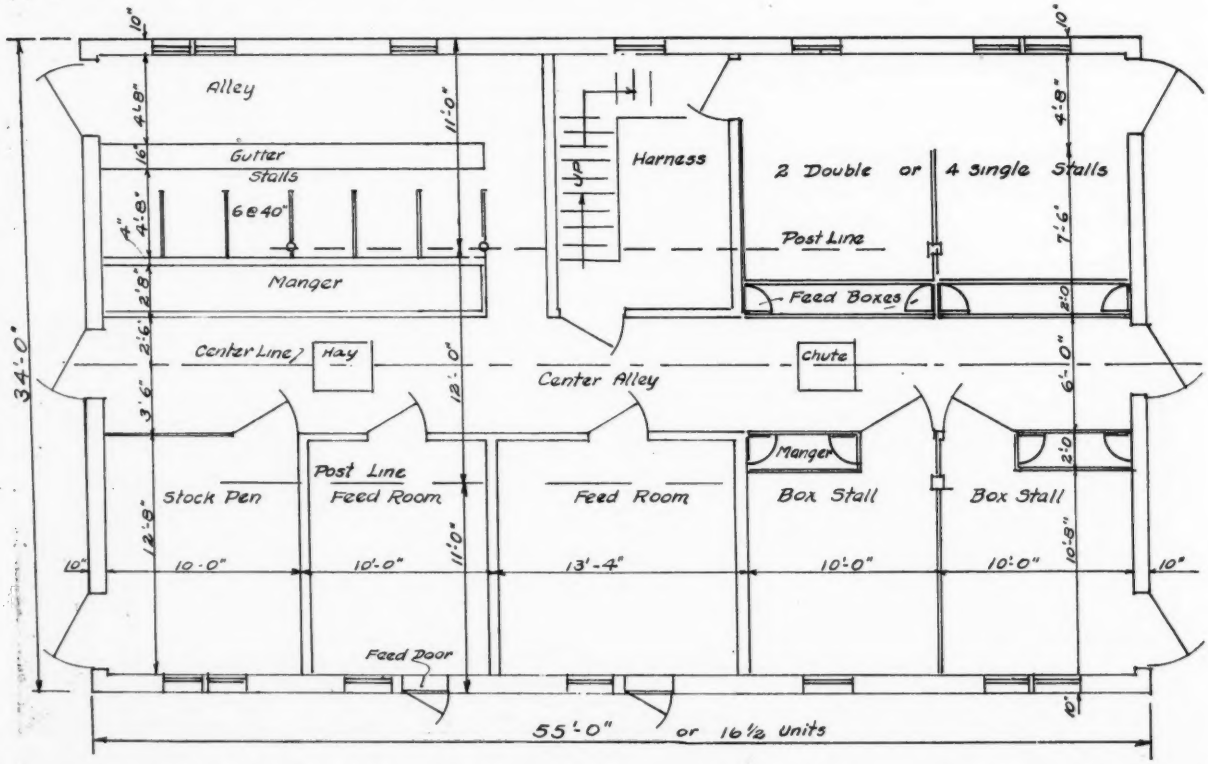


Fig. 5. A typical farm barn 34x55 ft. being built at Stuttgart, Arkansas, under the supervision of Mr. Carter. It illustrates the application of the space unit. The barn is 16½ units long

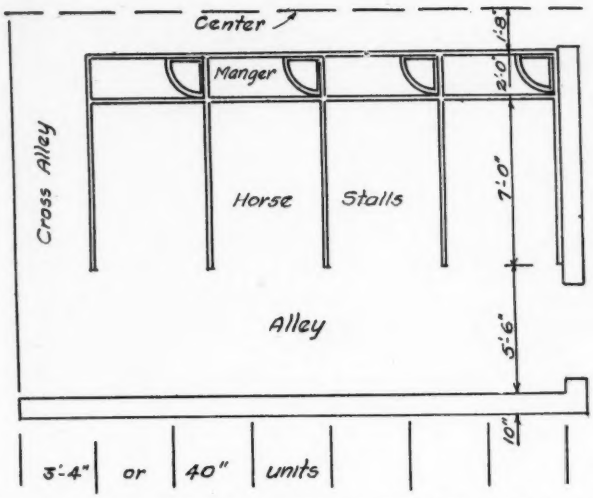


Fig. 3. Horse stall section. Combined with Figs. 1 and 2, the result is a typical general-purpose barn 68 ft. 4 in. long, including cross alleys and end walls

¼ unit = end wall
½ unit = two end walls
1 unit = cow stall, cross alley, stairs
1½ units = standing stall for horse
2 units = small pen; small feed room; harness room or store room
3 units = animal pen; feed room; box stall.

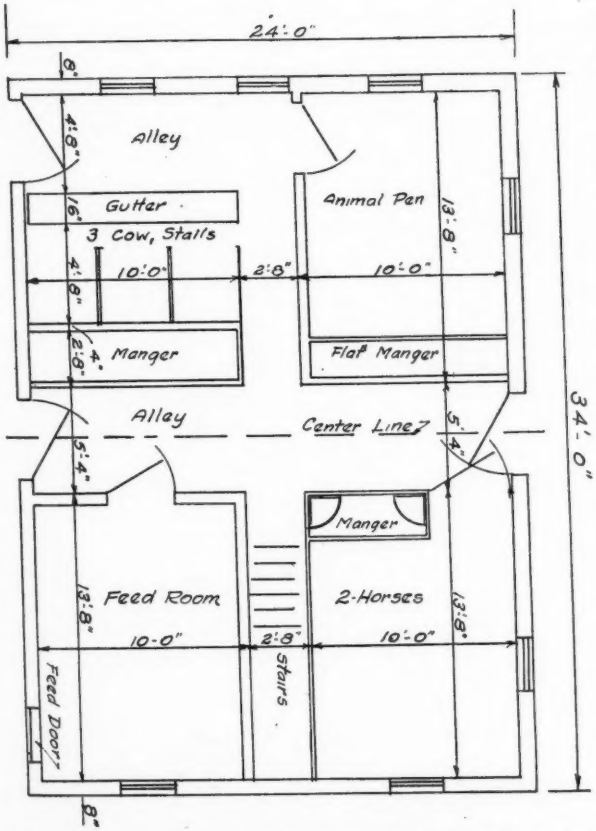


Fig. 6. The unit space can be applied to the small barn with practically no change. Allowing for walls and cross alley a standard size of 24x34 ft. provides six full units. Facilities are provided for 12 cows or 8 horses, or fewer animals in combination with pens or storage

If it is desired to make the barn an even number of feet in length, it is only necessary to see that the plan has one horse stall, and one cow stall in addition to other 10-ft. three-unit sections desired. The horse stall takes 1½ units; the cow stall 1 unit, and the end walls the remaining ½ unit to make even feet of length.

The Numerical Advantage of the Unit. Three feet four inches is equal to 40 in. Three units equal 10 ft.; 30 units equal 100 ft. Forty inches is divisible by 2, 4, 5, 8, 10, and 20. Whole, fractional, or multiple units are easily calculated. On a basis of three units the dimension of 10 ft. can be used to calculate materials lists and cost estimates. Forty inches is almost identical with the meter (39.37 in.), so the space unit may be used in its entirety under the metric system, with still further adaptability.

The Planning Advantage. The advantage of the space unit in planning is the complete adaptability to meet individual requirements. The addition of a single unit to the original plan provides room for one more cow on each side in the dairy barn. One and a half units gives the single-horse stall. Three units afford 10 ft. of additional room to be used as desired. Reductions from a given plan may likewise be made without affecting the general arrangement.

Ten-foot, or three-unit, sections are completely interchangeable with each other section. If the plan shows twelve cows, and only six are wanted, the dairy units are retained on one side and the pens or feed room placed opposite.

The plan units (Figs. 1, 2, and 3) show a typical layout of one-half the width of the 34-ft. barn. These sections taken together would afford a typical plan 68 ft. 4 in. long, providing for twelve cows, eight horses, and for box or pen sections. The right-hand portion (Fig. 1) affords a dairy barn; the left-hand part (Fig. 3) is a typical horse barn. Pens, boxes and feed rooms may be added to either portion.

Since both crosswise dimensions and lengthwise units are defined in the typical or basic plan, the application to a definite condition becomes merely a question of the proper arrangement of a sufficient number of units.

Application to Small Barns. The foregoing discussion assumes a farming condition in which the barn requirements justify a two-row arrangement and a length of at least ten units. The construction will then be the usual 34-foot gambrel, gable or Gothic frame, with or without hay storage above.

If this method provides a barn that is larger than the farm needs, as is the case in many southern communities, we have tentatively adopted the following plan: The same spacing of 34 ft. for two rows is used. However, the ridge is turned so 34 ft. becomes the length of the building. Twenty-four feet is then taken as the width, so a standard framing plan can be prepared. The construction is somewhat lighter, and 8-in. foundation walls are used. The usable space available is six full size space units, plus a 2-ft. 8-in. cross alley. In these six units there is room for twelve cows, or eight horses, or four pens and box stalls, or any combination of these groups.

General Application. This method of planning was presented this year to about fifty students, most of them college graduates, and was accepted by them. One student prepared a cross-section sketch blank with 10-in. (¼ unit) squares, and drawn to a scale of ¼ in. equals 1 ft. This gave a blank for sketching on a unit basis, and to the regular scale for working drawings. A 100-ft. dairy barn has just been completed on the experiment station farm at the University of Arkansas which was designed on the "unit space" basis. The construction of three other general-purpose barns is being supervised by the writer. They are from 55 to 65 ft. in length, and each conforms exactly to the space unit.

Since January 1, 1928, the typical 34-ft. unit plan and the "small barn" plan, 24x34 ft. have been the only plans used in answering barn planning requests sent to our department.

The Tractor Operated Corn Picker Saves Labor

EVERY year there are more than one hundred million acres of corn produced in the United States—far more than of any other crop. The work of harvesting this acreage of corn is a tremendous job and one which costs the farmers of the United States somewhere between $300,000,000 and $400,000,000 each season.

Picking corn by hand is especially a costly operation and one of the longest drawn out and most disagreeable jobs in corn belt farming. A man can plow from 5 to 15 acres per day, depending upon the equipment he is using. He can fit the seedbed at an even faster rate. By use of the all-purpose tractor and two-row and four-row planters, he can, respectively, cover 24 acres and 46 acres per day traveling at the rate of 3 mi. per hr. With two-row and four-row cultivators traveling at the rate of 4 mi. per hr., he can, respectively, cover 33 acres and 65 acres in a 10-hr. day. But if he picks his corn by hand, he can cover only 1 or 2 acres per day depending on the yield. With a tractor-operated mechanical corn picker and husker, however, he can cover 8 to 10 acres in a day and gather more corn than six average hand pickers.

To the Middle West farmer who has been accustomed to husking his corn from the standing stalks, throwing it directly into the wagon, hauling it to the crib, and dumping it into an engine-driven elevator, hand cutting and shocking will seem extremely inefficient. At the same time, the corn grower accustomed to harvesting his corn with a labor-saving mechanical corn picker and husker, pulled by tractor, the mechanism of which is operated by power taken directly from the tractor engine by power take-off device, considers all methods of picking by hand slow and burdensome and excessively wasteful of time, labor, and money.

The mechanical picker not only reduces the number of men required to harvest the corn, but also under most conditions just about cuts the cost of the work in half. At the same time, the disagreeable part of the work—the brushing against wet or frozen stalks and leaves and the snapping of the ears from the stalks by hand, which annually causes tens of thousands of sore hands—is entirely done away with. With modern equipment, about the hardest work connected with picking corn consists of driving a tractor or a team of horses.

One hundred dollars per year is a very liberal allowance for depreciation, interest, and repairs on a corn picker. If the machine is used on one hundred acres each year, therefore, the machinery cost per acre would be $1. On a 50-bu. yield, this would mean a machine cost of 2 cents per bushel. To this must be added the daily cost of the tractor, the wages of two men, and the expense of two horses for hauling the corn to the crib, assuming the tractor pulls the wagon while it is being loaded, as is a common and most efficient practice. Allowing $8 per day for the tractor, $4 per day for the men, and $2 per day for the horses, gives us an operating expense at $18 per day. Nine acres per day of 50-bu. corn gives 450 bu. per day, or 4 cents per bushel, which plus the 2 cents per bushel machine charge gives 6 cents per bushel total cost. In higher yielding corn, the cost would of course be correspondingly less. In many cases the cost is as low as 4 cents per bushel.

These figures compare with a charge of from 6 to 10 cents per bushel commonly made by transient labor for picking corn, to which must be added the cost of a team and usually at least part of the man's board, lodging, and laundry. The total cost for hand picking usually ranges from 10 to 12 cents, although in many instances it is even higher.

It is easy to see, therefore, that the man who uses a picker, especially if his farm is so organized as to use it efficiently, can save approximately 5 cents per bushel on the cost of picking. On 100 acres of 50-bu. corn this means a saving or profit, whichever one may wish to call it, of $250, to say nothing of the greater satisfaction of not having to hunt up men to do the picking and have them around the place for several weeks to be cooked for and looked after generally.

Cost Studies in Clearing Limestone Land[1]

By H. B. Josephson[2]

THE efficient use of machinery is hindered greatly by rocks in large sections of Pennsylvania and other eastern states. The cost of tractor plowing, for example, has been found to be from 50 to 75 per cent higher under typical stony conditions in central Pennsylvania than on land nearly free of rocks[3].

Cost studies on removing all large rocks that come within the depth of ordinary plowing were carried on at the Pennsylvania State College farms in the spring of 1928. This work was carried on with the cooperation of one of the manufacturers of explosives. All blasting was done under the supervision of a representative of the company.

Two acres of land were selected to represent, as nearly as could be determined, average conditions in the limestone area of the state. This land was divided into two equal parts and one acre was then cleared by drilling and blasting and one acre cleared, without the use of a drill, by mudcapping and snakeholing. Fig. 1 shows a plan of the field cleared giving the location of the rocks. A description of the field follows:

Plot I—Cleared by drilling and blasting

Sec. 1. Large flat rocks covering an area of about 10 by 18 ft.
Sec. 2. Solid ledge of limestone about 24 ft. wide and 30 ft. long having a maximum depth of about 5 ft.
Sec. 3. Boulders of various sizes up to about 4 ft. in diameter.

Plot II—Cleared without drilling

Sec. 1. Large rocks of considerable depth covering an area of about 15 by 20 ft.
Sec. 2. Large flat rocks.
Sec. 3. Large flat rocks with a maximum depth of about 3 ft.
Sec. 4. Boulders of various sizes.

Method of Procedure. The land was plowed early in the spring with a tractor to a depth of 9 in. A man followed the plow for the express purpose of marking the rocks. Each time the plow struck a rock the place was marked with a stake.

The next operation was that of clearing the soil off the rocks in preparation for placing the charges for blasting. This was done by the use of hand shovels.

A portable air compressor drilling outfit was rented from a local contractor and every rock on Plot I was drilled with a 1⅛ in. hole to a depth depending on the size of the rock. In the limestone ledge (Section 2) fourteen holes were drilled varying in depth from 42 to 52 in. (See Fig. 2). A small charge of dynamite packed in the bottom of a hole was found very effective. This method of using explosives is known as blockholing.

No drilling was done on Plot II. When possible the charge was placed under the rock by first boring a hole with a soil auger alongside of the rock. This method, known as snakeholing, was found very effective but required more dynamite than blockholing.

When the rock was too large to get a snakehole under it, mudcapping was employed. This method consists of laying a heavy charge of dynamite on top of the rock and covering it with several inches of mud. Snakeholing was more satisfactory than mudcapping whenever it could be applied, and a rock too large to snakehole was usually a poor subject for mudcapping. The only satisfactory way to handle such rocks was blockholing, but that method was purposely eliminated on Plot II. Fig. 3 is a photograph of Section 2, Plot II, before blasting. Seven snakehole shots were made, using 10½ sticks of dynamite. The result is shown in Fig. 4. The amount of rock removed was 3.7 cu. yd.

Explosives. Table I gives an itemized list of the explosives used, the number of shots, types of shots and cost. The economy of the blockholing method in the use of explosives is shown by the fact that on Plot I 31 cu. yd. of rock were removed at a cost of $4.49 for explosives, while it cost $7.43 to remove 18 cu. yd. on Plot II.

Labor. The distribution of labor in clearing this land is given in Table II. The total labor was 80 man-hours per acre on Plot I and 63.5 man-hours per acre on Plot II. The distribution of labor on Plot I was as follows: Uncovering rocks, 15 per cent; drilling, 15.6 per cent; blasting, 12.5 per cent; quarrying, 30.1 per cent; hauling, 20.5 per cent, and filling holes, 6.3 per cent. On Plot II. the distribution of labor was: Uncovering rocks, 14.2 per cent; blasting, 25.1

TABLE I. Explosives Used

Plot I	No. of shots	Types of shots*	No. of of cartridges	Fuse, feet	No. of caps	Cost of explosives**	Total rock removed, cu. yd.
Sec. 1	4	b.h.	5	5	4	$ .45	4.1
Sec. 2	13	b.h.	35	16	13	2.87	20.0
Sec. 3	14	b.h.	12	18	14	1.17	6.9
Total Plot I	31		52	39	31	4.49	31.0
Plot II							
Sec. 1	10	(7—s.h. 3—m.c.)	28.5	12	10	2.33	5.3
Sec. 2	7	s.h.	10.5	9	7	.93	3.7
Sec. 3	8	(3—s.h. 5—m.c.)	27.5	10	8	2.21	2.5
Sec. 4	14	(10—s.h. 4—m.c.)	22.5	17	14	1.96	6.5
Total Plot II	39		89.0	48	39	7.43	18.0

*Abbreviations: b.h.—blockhole; s.h.—snake hole; m.c.—mud cap.
**Cost of Explosives: Dynamite—$15.00 per 100 lb.; Fuse—$7.80 per 1000 ft., less 17½% discount; Caps—$14.00 per 1000, less 20% discount.

[1]Third of a series of six articles based on the results of a power and labor research study at the Pennsylvania State College. Released for first publication in AGRICULTURAL ENGINEERING as Technical Paper No. 456 of the Pennsylvania State College, School of Agriculture and Experiment Station.

[2]In charge of farm machinery research, Pennsylvania State College. Mem. A.S.A.E.

[3]"Tractor Plowing in Stony Ground," AGRICULTURAL ENGINEERING, Vol. 9, No. 8 (August, 1928).

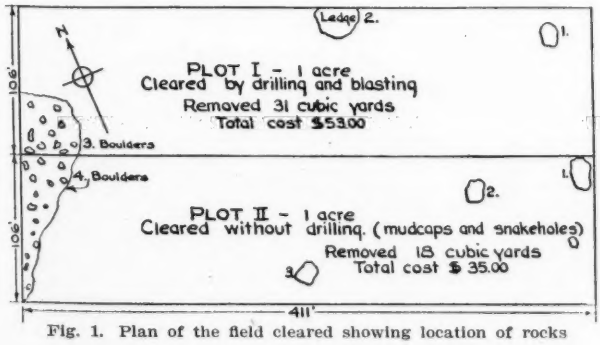


Fig. 1. Plan of the field cleared showing location of rocks

Fig. 2. Drilling a limestone ledge on Plot I, Section 2, using compressed air

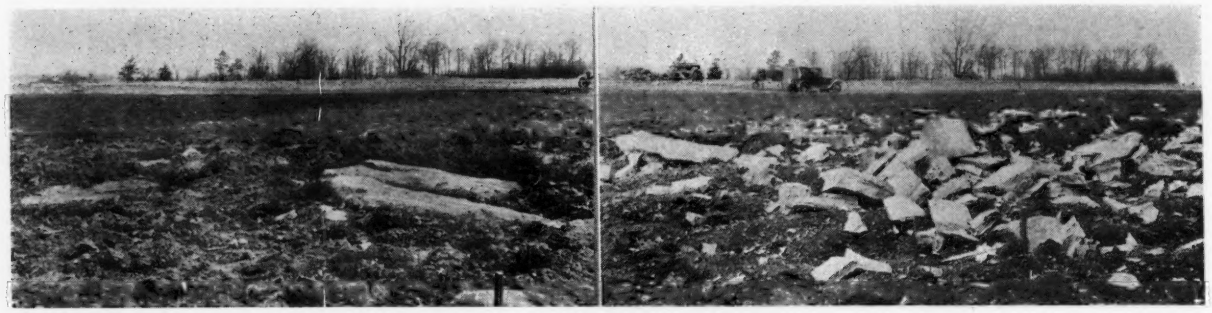


Fig. 3. (Left) Typical limestone rocks in Plot II, Section 2, before blasting. Ten and one-half sticks of dynamite in seven snakehole shots were used. Fig. 4. (Right) The same after blasting. The blast removed 3.7 cu. yd. of rock

per cent; quarrying, 19.7 per cent; hauling, 33.1 per cent, and filling holes, 7.9 per cent. In both cases the labor of removing the rocks after blasting (quarrying and hauling) was over 50 per cent of the total labor. The quarrying was done by hand using picks and bars for removing the broken fragments of rocks that remained in the ground. The quarrying was especially difficult where mudcapping had been done. The rocks were hauled from the field using a tractor and a large flat-bottomed stoneboat.

TABLE II. Man Hours of Labor per Acre

	Plot 1		Plot 2	
	Man hours per acre	Per cent	Man-hours per acre	Per cent
Uncovering rocks	12.0	15.0	9.0	14.2
Drilling	12.5	15.6		
Blasting	10.0	12.5	16.0	25.1
Quarrying	24.1	30.1	12.5	19.7
Hauling	16.4	20.5	21.0	33.1
Filling holes	5.0	6.3	5.0	7.9
Totals	80.0	100.0	63.5	100.0

Power. A tractor was used for hauling the rocks from the field and for pulling a scraper used for filling the holes left by the rocks. The cost of using the tractor was $6.64 per acre on Plot I and $8.85 per acre on Plot II. (See Table III.)

TABLE III. Cost for Use of Tractor per Acre

	Plot I		Plot II	
	Amount	Cost	Amount	Cost
Hauling rocks	8.2 hr.		11.7 hr.	
Filling holes	1.7 hr.		2.0 hr.	
Total hours	9.9 hr.		13.7 hr.	
Kerosene	7.4 gal.	$1.04	9.6 gal.	$1.35
Gasoline	1.5 gal.	.33	1.5 gal.	.33
Oil	.75 gal.	.32	.75 gal.	.32
Fixed cost at 50 cents per hr.		4.95		6.85
Total cost		$6.64		$8.85

Cost. The total cost of clearing Plot I was $53.22 per acre and Plot II $35.08 per acre. (See Table IV.) The total volume of stone removed was 31 cu. yd. for Plot I and 18 cu. yd. for Plot II. The cost per cubic yard of rock removed was slightly less on Plot I where the rocks were drilled, being $1.72 per cu. yd. as compared with $1.95 per cu. yd. on Plot II where no drilling was done.

The cost of using the drill was $3.50 per hour for the machine and two men. This is the price charged by the contractor. It is probable that this cost might be reduced considerably if undertaken on a large scale.

This preliminery study would seem to indicate that drilling is practical where large rocks are prevalent.

Table IV shows the distribution of cost in clearing the land. On Plot I the distribution was as follows: Labor, 38 per cent; drilling, 41 per cent; tractor, 12.5 per cent; and explosives, 8.5 per cent. On Plot II the distribution was as follows: Labor, 53.6 per cent; tractor, 25.2 per cent; and explosives, 21.2 per cent. Of special interest is the low cost of explosives on Plot I, where drilling was done, being only 8.5 per cent of the total cost. Labor is the big cost item.

TABLE IV. Cost of Land Clearing

	Plot I Drilling and blasting		Plot II Mudcapping and snakeholing	
	Cost	Per cent	Cost	Per cent
Labor at 30 cents per hr.	$20.22*	38.0	$18.80	53.6
Drilling	21.87**	41.0		
Tractor	6.64	12.5	8.85	25.2
Explosives	4.49	8.5	7.43	21.2
Total cost per acre	$53.22	100.0	$35.08	100.0
Volume of rock removed	31 cu. yd.		18 cu. yd.	
Cost per cu. yd.	$1.72		$1.95	

*Not including labor in drilling.
**Machine and two men 6¼ hr. at $3.50 per hour.

Possible Improvements in Methods. It is probable that a cheaper method of drilling could be developed than that employed in this experiment. A small air compressor unit might be attached to a farm tractor making a portable drilling outfit which would not require a separate power unit. A small drilling outfit, using for its motive force the impulse of a gasoline-driven piston has recently been developed and would appear to have possibilities in providing a cheap method of drilling rocks.

Special equipment should be developed to use with a tractor for dragging out rocks after blasting, scraping the soil off the surface of the rocks before blasting and filling the holes.

In the limestone area of Pennsylvania where these studies were made the land has been farmed for many decades. The soil is rich and rainfall is plentiful. Drainage is seldom required. This land is frequently used for such crops as potatoes, yielding high returns per acre. Improved mechanical methods of tillage and harvesting cannot satisfactorily be used under such stony conditions. It would seem, therefore, that the cost of removing these rocks, as determined from this study, is not prohibitive, and if these costs can to any considerable extent be reduced by improved methods, land clearing should become one of the most important branches of agricultural engineering in Pennsylvania and where similar conditions exist in other eastern states.

Power Competition

A FARMER cannot today afford to hire a man at prevailing rates of wages to drive only two horses, for he is competing against other farmers whose hired hands are using a great deal more power and thus accomplishing a great deal more per day. A fair day's work changes with the times and conditions. When two horses formed the largest team used for farm work, plowing two acres per day constituted a good day's work. In these days, with thousands of farmers all over the world using tractors, a full day's work in plowing is from ten to fifteen acres, and in disking, seeding, harvesting, etc., the work accomplished in a day should be on a corresponding basis.—From "Better Fruit"

Hay Harvesting Methods in Oregon[1]

By H. E. Selby[2]

THE facts and figures presented in this paper have been obtained in a statewide study of methods and costs of producing forage in Oregon that has been carried on by the farm management department of the Oregon Agricultural Experiment Station covering the years 1925, 1926 and 1927. In the three years over 1100 annual farm records were taken. Data were obtained upon the methods and costs of producing over 1500 separate farm crops of hay and other forage aggregating over 50,000 acres. While costs of production, which constituted the main object of the study, doubtless would be of considerable interest to agricultural engineers, it will be impossible to discuss them in this short paper, which will be devoted only to that phase of the study dealing with our western hay harvesting methods and equipment.

There is wide variation in haying methods and in haying machinery and equipment in Oregon. At one extreme we have cases of two men hauling with a wagon and handling the hay by hand. At the other extreme we have stacking crews of a dozen men, six or eight teams, a thousand dollars worth or more of specialized haying equipment, and handling the hay entirely with machinery except for men on the stack.

This variation in methods and equipment does not begin however, until after the hay has been mowed and raked. Machinery used for mowing and raking is quite uniform and standardized. The 5-ft. mower and the 10-ft. sulky dump rake are used almost exclusively. There are some exceptions of wider and narrower sizes of these implements, some side-delivery rakes are used, and there are a few rare cases of tractor mowing. Some of these exceptions will be referred to later.

Methods of handling the hay after it has been mowed and raked must be considered according to three kinds of hay production in the state, as follows: (1) Alfalfa hay in the irrigated regions; (2) clover hay and vetch and oats hay in the Willamette Valley, and (3) wild or native hay from natural hay meadows, chiefly in the central and southeastern part of the state. Of over a million acres of hay produced in Oregon, irrigated alfalfa is roughly one-fourth, the Willamette Valley clover and vetch is another fourth, and the wild hay comprises something over one-tenth.

We will consider first the alfalfa hay in the irrigated regions. This hay is mostly stacked in the open instead of being stored in barns. Some of it is baled directly from the field, but more of the baling is from the stack, so as to allow the hay to go through a stack sweat.

Three kinds of equipment are used in hauling the alfalfa hay; namely, wagons, slips, and buckrakes. Wagons are used especially by growers with small to medium-sized acreages and where the hay is hauled a considerable distance from the field to the stackyard or barn. Slips and buckrakes are used especially for stacking in or adjacent to the field. Forty-five per cent of the hay was hauled with wagons, 25 per cent with slips and 30 per cent with buckrakes.

Hay slips are homemade contrivances commonly consisting of eight 1x12's 16 ft. long, nailed together with a crosspiece at each end. These simply slide over the hay stubble and obviously are not adapted to long hauls nor to traveling through lanes or roads. Their principal advantage is that they can be loaded easily by one man.

Some growers add a pair of low wheels to the slip to lighten the draft. These are usually set a little ahead of the center so that the rear end of the slip drags lightly on the ground. The wheels are not desirable, however, where a practice is made of corrugating or furrowing the alfalfa for irrigation, as they break the corrugations and also make the slip pull unevenly.

In using both wagons and slips the hay is usually cocked by hand from the windrows, pitched onto the wagon or slip by hand, and unloaded either with slings or a hay fork. Very few side-delivery rakes and hay loaders are used. For alfalfa hay the fork used almost exclusively is the Jackson fork. Slings were used by about one-third of the growers who hauled with wagons and by two-thirds of those who hauled with slips. An average of a third of a ton more hay was stacked per man per day by stacking crews using slings.

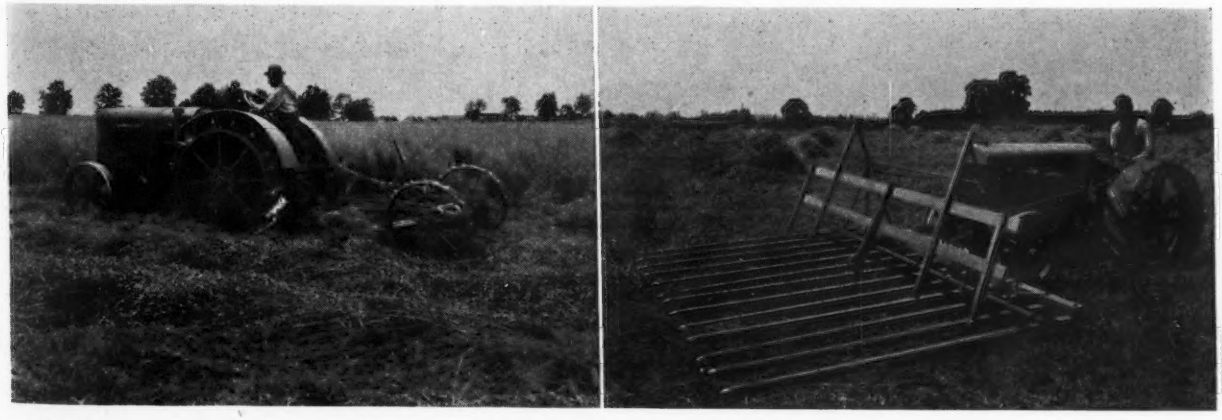
The average amount of labor for hauling and stacking was slightly less with slips than with wagons. The average length of haul, however, was less with the slips, and when this is taken into consideration the slips have very little labor-saving advantage. Apparently the ease of loading the slips is largely offset by the larger loads hauled with the wagons.

The buckrake method of handling hay is a large scale method, more commonly used for the larger acreages of alfalfa. The hay is sometimes cured in the windrow and then put directly into the stack. More often, however, it is bunched into large piles, sometimes with a dump rake but usually with a buckrake, and allowed to cure in these bunches. A few growers make a practice of shaping up the bunches by hand.

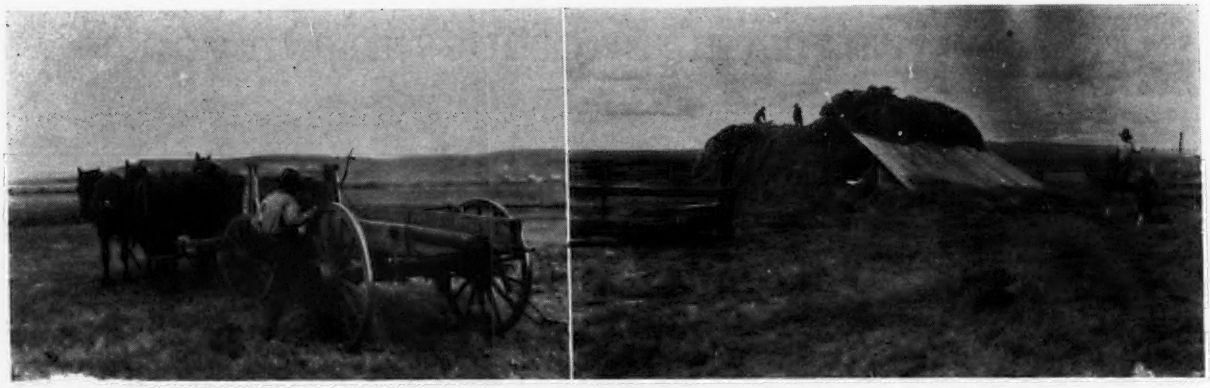
The buckrake method of putting up hay is about 50 per cent more efficient in the use of man labor than hauling with wagons or slips. Crews using wagons and slips stacked

[1]A contribution to the symposium on haymaking methods and equipment presented at the Power and Machinery Session of the 22nd annual meeting of the American Society of Agricultural Engineers at Washington, D. C., June, 1928.

[2]Associate in farm management, Oregon Agricultural Experiment Station.



(Left) This tractor mowing outfit has been used successfully to cut over 100 acres of hay each year for the past three years. (Right) Thirty tons of hay a day is hauled to the baler by one man with this tractor and buckrake



(Left) Gin wagon used for pull-up in stacking wild hay with a slide stacker. (Right) Stacking wild hay with a slide stacker

an average of 3½ tons per man per day, while those using buckrakes averaged 5 tons per man.

Offsetting the big labor-saving advantage of the buckrake, however, there is a big question as to the comparative quality of buckraked and hand-shocked hay. Upon this point there is considerable difference of opinion among growers and hay men, many claiming that it is impossible to make as good hay with buckrakes, while others claim to be able to make just as good or even better hay, by using right methods. Undoubtedly it is possible to make just as good hay with buckrakes, but it is a matter of common observation that in actual practice buckraked hay is often of inferior quality. The cause of some of this poor quality is undoubtedly the tendency of some growers who raise hay for sale to let it get too dry before stacking in order to get a larger stack-measurement; but often the hay becomes too dry unavoidably.

Since this factor of the quality of the hay is of vital importance, particularly when affecting the use of such efficient equipment as buckrakes, let us briefly consider the causes of the poor quality and methods necessary to avoid them. The poorer quality of buckraked hay arises chiefly from (1) the loss of leaves in handling because of being too dry, and (2) the picking up of dirt as the hay is pushed across the field.

To prevent loss of leaves the hay must not become too dry at any stage of the haying. It should be raked as soon after mowing as possible, and before it becomes too dry in the windrow it should be bunched into large bunches, in which it should cure only enough for stacking. A better quality of buckraked hay can be made in a region of cooler nights with considerable dew, where the hay will cure more slowly, than in a hot dry region where the hay dries out rapidly. Care must be taken in bunching and bucking the hay to avoid rolling and mauling it and thus shattering the leaves.

The practice of "yarding" the hay, or moving the bunches together at the time of bunching into a small area around the place where the hay is to be stacked, helps to save leaves by making a shorter haul after the hay is cured. This practice also makes possible a smaller stacking crew, since with the hay close at hand fewer buckrakes are necessary to keep the stacker going at full capacity.

The amount of dirt in buckraked hay depends upon conditions of the field and the methods used. If the soil is cloddy, more dirt will be picked up than if it is sandy, as the sand sifts out. More dirt will be picked up on a meadow that has been spring-toothed than upon an uncultivated field. Very clean hay can be made when the stand of alfalfa is thick and even, and has not been cultivated. Irrigating just before haying, so that the ground will be moist instead of dusty, helps considerably. Taking smaller loads that can be lifted clear of the ground with the buckrakes, also makes for cleaner hay, but slows down the speed of haying to some extent.

A practice that is being tried by a few growers to avoid pushing the hay across the field with buckrakes, and still avoid hand pitching, is using slips for hauling, but loading them in the field with a buckrake. A board is attached to the rear end of the slip as an apron so that the buckrake can be driven upon the slip to dump the hay. At the stack the slip is driven upon a net spread upon the ground, a rope is stretched between two posts in front of the load, and the slip is pulled out from beneath, dropping the hay upon the net.

The use of buckrakes seems to be decreasing in Oregon in spite of its labor-saving advantages. The reasons for this seem to be the decrease in production of alfalfa hay for market and the breaking up of large acreages of hay with increasing diversification. As the acreages become smaller, expensive machinery is not justified, and many farmers as they begin to feed more of their hay to dairy cows find that they prefer to put it up by hand.

Homemade derricks of a great variety of designs are used for stacking with wagons and slips. Most of these fall into two general types. The first and most numerous is the so-called Mormon derrick type, of which the distinctive characteristic is that the boom is placed upon the top of the mast. These are made with a base and are the more easily moved from place to place. In building the Mormon derricks, there is need for a good manufactured turntable or rowlock, the iron and steel joint that connects the top of the mast with the boom. These joints are usually crudely made from scrap iron by the farmer or local blacksmith and are often of poor design. Farm implement makers might supply them to advantage.

The second type is the mast-and-boom type, in which the boom extends from the side of the mast. The mast is supported by guy wires from the top. They usually do not have a base and therefore must be raised and lowered when moved, but they can be constructed to build larger stacks and to lift larger loads, because of the support of the guy wires. A mast and boom derrick with a small base, which has been called a Wilson derrick, is found occasionally. A third type of stacker, which is found less frequently, is the cable stacker.

Derricks are used to some extent for stacking hay with buckrakes and have the advantages of being cheaper and of making large stacks, but are not quite so efficient as the patented stackers. Two methods are employed in using them. One is to buck the hay to the stack and then fork it with a Jackson fork. The other is to buck the hay onto a net or hay sling spread upon the ground with which it is then lifted to the stack.

Manufactured stackers are usually used with buckrakes. Of these the Jenkins swinging stacker is the most common in Oregon. There are also many Dain overshot and Jackson overshot stackers, and stackers of other makes. It is possible to put up larger stacks with the larger types such as the Jenkins and Jackson stackers, and many growers prefer them for this reason. Many others, however, prefer the Dain overshot type because of its comparative simplicity and the ease with which it is operated and moved. It is used to greatest advantage where numerous stackyards can be scattered over the hay meadow. The swinging stackers have the advantage that the hay can be dropped at different places on the stack, thus making less work in stacking.

The biggest complaint about all of the patent manufac-

tured stackers is that they are not made strong enough. It is a common practice after paying between two and three hundred dollars for a new stacker, to put forty or fifty dollars into strengthening and reinforcing it before it is used. There is a demand for a stacker for use with buckrakes that will stand up under heavy loading.

Combination buckrakes and stackers are used by a number of growers. These outfits, while rather high in first cost, have the great advantage for small farms of making it possible to put up the hay crop with very little extra hired labor. With a limited acreage the grower can mow, rake, bunch and yard his hay alone. He can then stack it with only one extra man, one man operating the stacker and the other stacking. This seems to be the chief place for this kind of stacker.

The number of men in the stacking crew was found to have very little to do with its efficiency. The only advantage of larger crews seems to be putting up more hay in a shorter time. On the average, small crews and large crews stack about the same amount of hay per man per day.

We come now to the production of clover hay and vetch and oats hay in the Willamette Valley. This hay is all put into barns, with the exception of hay that is baled directly from the field or stacked temporarily and then baled. The hay is hauled almost entirely with wagons and is unloaded with forks or slings. The double harpoon fork is used most commonly, although the single harpoon, grapple fork, and Jackson fork are used occasionally.

A few side-delivery rakes and hay loaders are found in this region, but less than 10 per cent of the hay is put up by this method. The biggest obstacle to their more general use is the cost of the equipment, which is hardly justified by the amount of hay on the average farm.

A few cases of tractor mowing are found but they are exceptional. As an example of what can be and is being done, there is the case of Ed Jensen, near Eugene, who last year mowed 255 acres of vetch hay in 11 days with a 6-ft. mower attachment. A horse mower was used to mow out headings and irregular corners. Other cases similar to this indicate that it is possible to mow more than twice as fast with a tractor as with a team, and it is to be expected that as tractor-mowing equiment is improved and perfected the use of it will increase. With mower attachments driven directly from the tractor, there has been considerable breakage, and traction mowers pulled by the tractor are not entirely satisfactory because of clogging and difficulty of operating without an extra man on the mower. Another reason why tractors are not used more for mowing is that horses that would otherwise be idle usually are available for mowing.

There seems to be more cases of hauling hay from the field to the barn with motor trucks than there are of tractor mowing, at the present time. This practice is sometimes efficient in hauling from distant fields.

One grower last year used a buckrake on a Fordson tractor to very good advantage in baling from the field, hauling 30 tons a day with the outfit, or the work of three men with teams. The same man also used a garden tractor on his hay rake, but this would seem to be more a novelty than an effective practice.

Perhaps the most interesting development in hay harvesting methods in the Willamette Valley, and one that seems to be increasing, is the practice of chopping hay into barns directly from the field. Feeding trials show considerable extra value for chopped hay, and the practice has the additional advantage of greatly increasing the storage capacity of the hay mow. Out of 148 farms putting up clover or vetch hay that were studied in 1927 there were eight that followed this practice.

The hay is thoroughly cured in the field and chopped and blown into the barn with an ensilage cutter. On the eight farms the average amount of hay chopped into the barn was 3½ tons per man per day, approximately the same rate at which unchopped hay was put in. With the blower it is not necessary to have men in the mow, and this saving apparently makes up for the extra work of putting the hay through the cutter. The only extra cost of chopping, then, is for the use of the cutter and tractor, which is small if the farm already has this equipment.

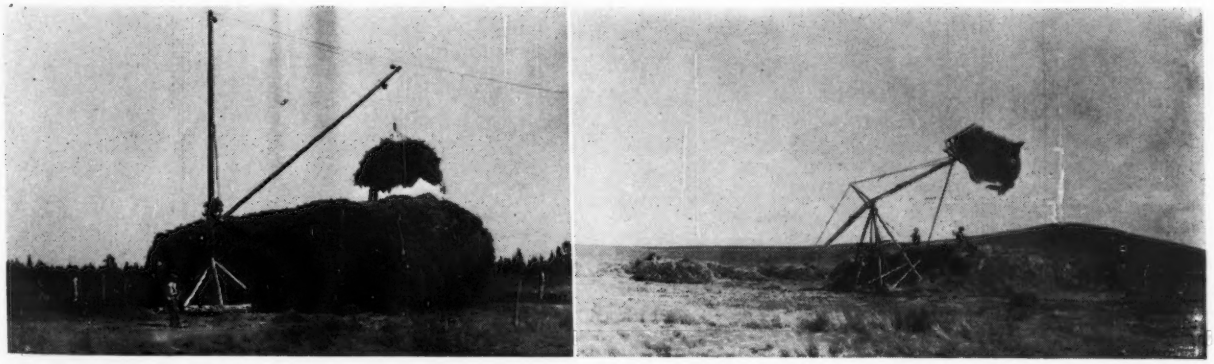
In eastern Oregon alfalfa hay that has been stacked is sometimes chopped and then restacked. The chopped hay is said to keep satisfactorily in the stack, shedding rain better than unchopped hay. It would seem that costs might be reduced by chopping the hay into the stack directly from the field.

Lastly, we have the production of wild or native hay, and in connection with this we will consider only a unique and interesting method that is extensively used, particularly in the Harney Valley, and that is highly efficient for this kind of hay. This is the method of stacking with slide stackers.

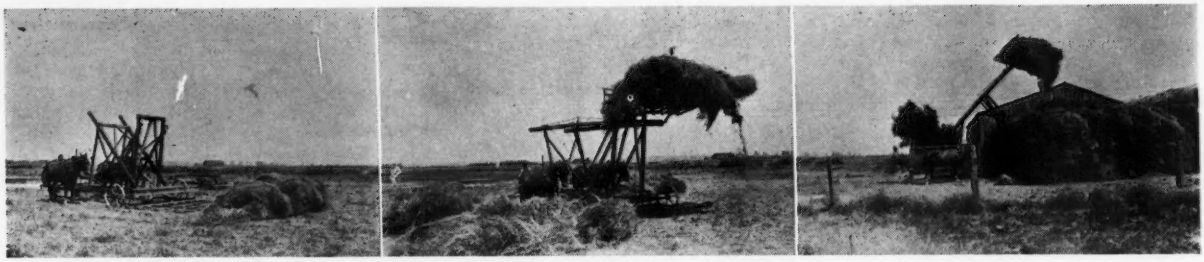
The slide stacker used is simply an incline 10 or 12 ft. high, built of lumber. This is placed at one end of the stack and the hay is simply pulled up this "slide" with a large chain net and a cable which extends from the net up the slide and over the stack to the pull-up at the other end.

The net is made of chains which are spread apart by a wooden pole. In setting the net to receive the hay this pole is placed in a trench dug in the ground, and the hay is bucked over it onto the chains. In the larger outfits four-horse buckrakes are used, which will handle as much as a ton of hay at a time.

After the hay has been bucked upon the net, the end of the net is thrown over it and the ends of the chains are engaged by a hook on the end of the cable. The load is pulled up by a four-horse team on a wagon called the "gin wagon." The cable is fastened to a trip called the "toggle" at the back end of the wagon. The load of hay is pulled up the slide and along the top of the stack to the position desired, when the "toggle" is tripped and the hay is released from the net. The net and cable are then pulled back by a man or boy on horseback, who takes a turn around his saddle horn with the pull-back rope and drags them back at a gallop. The only men in these crews that have any use



(Left) The Wilson derrick is essentially a man-and-boom derrick with a small base to facilitate moving. (Right) This shows a Jenkins swinging stacker with a load of hay swung over the stack and being dumped



Three views of the combination buckrake and stacker in action. (Left) Picking up the hay, (middle) carrying the hay to the stack, and (right) dumping the hay on the stack

for a pitchfork are the men on the stack, and they use them mostly to guide the cable so as to pull the load to the right place on the stack.

The average amount of wild hay stacked per man per day by this method was over 7 tons, as compared with 5 tons of alfalfa hay with buckrakes and 3½ tons with wagons and slips. The more efficient crews, of course, exceed these average rates of stacking. Unfortunately, the four-horse buckrake and slide stacker method is not adapted to alfalfa hay, as the leaves are shattered by the rough handling, and the hay is not spread out thoroughly enough in the stack. For wild hay, however, it seems to be quite satisfactory.

In this paper the author has endeavored to give briefly a bird's-eye view of the kinds of equipment and the methods used in harvesting hay in Oregon at the present time, as obtained incidentally to the three-year study of costs of producing forage crops that is just being completed. The facts that have been presented call attention to three conditions that seem to be outstanding in connection with hay harvesting machinery. First, the use of buckrakes seems to be decreasing, notwithstanding their efficiency, because of reduction of acreages and a question as to the quality of hay produced with buckrakes. Second, the use of tractors for mowing seems likely to increase as tractor-mowing equipment is improved. Third, the practice that seems to offer the greatest possibilities of development is that of chopping hay directly from the field into the barn or stack. These conditions might suggest to the agricultural engineer the following possibilities of improving haying methods and cutting their cost: (1) Improvement of buckrake haying machinery and methods of use to overcome difficulties now experienced in making hay of good quality; (2) improvement of tractor-mowing equipment; (3) development of special equipment and methods for chopping hay directly from the field into the barn or stack, possibly similar to the Ronning system of harvesting corn ensilage.

Improved Quality and Reduced Cost Needed in Hay Production[1]

By H. B. Walker[2]

NO SINGLE crop is grown so generally in the United States as hay. In spite of this, probably no major crop has received less attention from the standpoint of production methods. The peculiar circumstances surrounding our hay production have tended to detract from its importance.

Hay and forage, exclusive of corn forage, exceeds the value of all other crops in twenty-four states. These are second in value in eleven states, and third in value in seven states. Twenty-three per cent of the improved land of all farms is devoted to these crops and they represent about one-sixth of the total value of all crops in the United States.

Hay is a pioneer crop as well as a crop coming from the intensive development of a region. It stands first in such states as Idaho and South Dakota, as well as in the oldest settled regions such as the New England states.

The fact that hay does not go directly into food products is probably one of the important reasons why it has received so little attention. Furthermore, the hay crop up until the time of harvest does not require much labor input. During the past decade and a half, however, labor costs have been constantly mounting and the demand for quality hay increasing. The tendency toward less beef production and more dairy production has developed the demand for quality forage. This demand for quality, coupled with high labor charges, makes the harvesting and processing of hay one of the most important tasks in agricultural production.

During the past year I have had an opportunity to observe the interest in haying methods throughout the United States. Practically every state agricultural experiment station visited expressed an interest in hay production from the standpoint of high quality at low cost. In the east half of the United States the interest was particularly keen in the artificial curing of hay. Some of these states, including New Jersey, Indiana, Texas and Louisiana, have conducted experiments with artificial drying processes. Undoubtedly this is a problem demanding the most careful analysis through experimental and research methods. This problem is particularly important for the eastern and southern states.

The western states apparently are showing more interest in improved field practices for natural methods of hay curing. Mechanical equipment is being extensively used with the objective of a hay product which will be able to compete with artificially cured hay. These studies offer great promise for the western producer where sunshine is normally abundant during the harvest season.

Kansas is interested in hay production. Geographically, our location is such that we cannot afford to ship poor hay, because the freight charge on a ton of inferior hay is as much as for a ton of high quality. Studies are being made at the Kansas station this year on methods and costs of making hay with mechanical equipment and in addition some preliminary studies are to be made on curing hay with artificial heat.

It would seem desirable in all of these hay production studies that the closest cooperation should prevail. This applies particularly to artificial drying. There are great opportunities to improve quality and reduce the cost of this crop. This is an interesting and attractive field for cooperative studies between the agronomy and agricultural engineering sections of the land grant experiment stations.

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[1]A contribution to the symposium on haymaking methods and equipment presented at the Power and Machinery Session of the 22nd annual meeting of the American Society of Agricultural Engineers, at Washington, D. C., June, 1928.

[2]Formerly professor of agricultural engineering, Kansas State Agricultural College, now professor of agricultural engineering, University of California. Mem. A.S.A.E.

How Hay is Harvested in California[1]

By E. J. Stirniman[2]

A QUARTER of California's acreage is classed as lands in farm. Only 8,401,324 acres are classed as crop land, of which only approximately 5,722,800 acres were harvested during 1924, the remaining area being either idle or fallow land. The average size of farm is 201.7 acres.

The value of all crops produced in 1924 was reported as $154,883,599. The acreage of the hay and forage crops exceeded that of other grain, forage and miscellaneous crops, which includes wheat, corn, barley, rice, cotton, sugar beets and potatoes. The hay acreage was divided into the following classes: Small grains cut for hay, 850,829; alfalfa, 739,457; wild grasses, 113,619; other tame grasses, 85,853; timothy and clover mixed, 19,867; sweet clover, 4,826; timothy, 3,985; red clover, 3,144; annual legumes, 43. (These figures are from the U. S. Census of Agriculture, 1925.)

The annual legumes were given as soybeans, cow peas and peanuts. No doubt the acreage would far exceed that listed if other legumes grown in the state had been properly classed. The acreage of grain hays also includes such items as sorghums and corns cut for silage, hay or fodder. Allowance should be made for these facts when comparing acreages of hay, grain and forage crops.

The state of California presents at least three different areas for the hay crop. Geographically, they are (1) the northern and eastern or mountainous section; (2) the central interior valleys, which mean the main agricultural sections of the state drained by the Sacramento and San Joaquin Rivers; and (3) the southern section comprising the Antelope and Imperial Valleys. The references to Los Angeles and the southern section might be confusing unless we remember that Los Angeles is the market for hay raised in the valleys perhaps one hundred miles away.

Comparison of Yields. Considerable spread is found in the production per acre in the different sections of the state. The counties in the interior valleys have the larger acreage of alfalfa and grain hays and the greater yield in tons per acre, averaging approximately 3½ tons, while the northern and coast counties, which have the greater acreage in native grasses, show an average yield as low as ½ ton per acre. The number of cuttings varies from one in the native grasses and grain hays to six or seven (maximum) in irrigated alfalfa.

The method of handling the wild and native grasses in the northern part of the state is quite different from that employed in the interior valleys where the major crop is either alfalfa or grain hay. Approximately 90 per cent[3] of the cereal hay crop of California is fed in the locality where it is produced and an even larger percentage of the native grasses is fed locally. The cereal hay crop is comprised, in a large part, of the cuttings around the grain fields made to accommodate harvester lanes to admit the combine on its first round. By this practice the cereal area is somewhat reduced. It is estimated that 18,000 to 20,000 acres of hay grain is cut each year by this practice. The system used in trimming and cutting lanes in grain fields does not conveniently lend itself to the use of the more efficient hay tools such as large mowers, side-delivery rakes, hay loaders, combination loaders and balers, etc.

Cutting Hay. The majority of the hay crop in the northern and coast areas is cut with horse-drawn mowers of the 5 to 6-ft. size. Very few tractor-driven mowers are used. This may be explained partly by the fact that the counties having a majority of the native grass area do not have many tractors. The fields in most cases are small and irregular, the hay cut around wooded lots and in a large measure from stump farms. The cutting equipment for grain hay in the interior valleys, which is principally in grain hay and alfalfa, is the 6 to 8-ft. horse-drawn mower. The few tractor-drawn units used have been introduced within the last two years.

The combine-harvester header can be used for cutting and windrowing grain hays. By this system a wide swath is cut and placed in a windrow on top of the stubble, which affords a means by which the air can better circulate for curing it. In one instance in the coast area, a combine was used for windrowing grain hay, the concaves being removed and the grain run through the machine and deposited on the ground in a windrow. This was done to partly crush the straw to hasten its drying.

Another new method of cutting hay has been introduced in the south[4]. The alfalfa was allowed to pass through a set of rollers placed back of the cutter bar. It was stated that by thus pressing the hay it would dry in 30 hr., as compared to 62 hr. for cutting alone. It also had a better color since it was exposed to the sun for a shorter period.

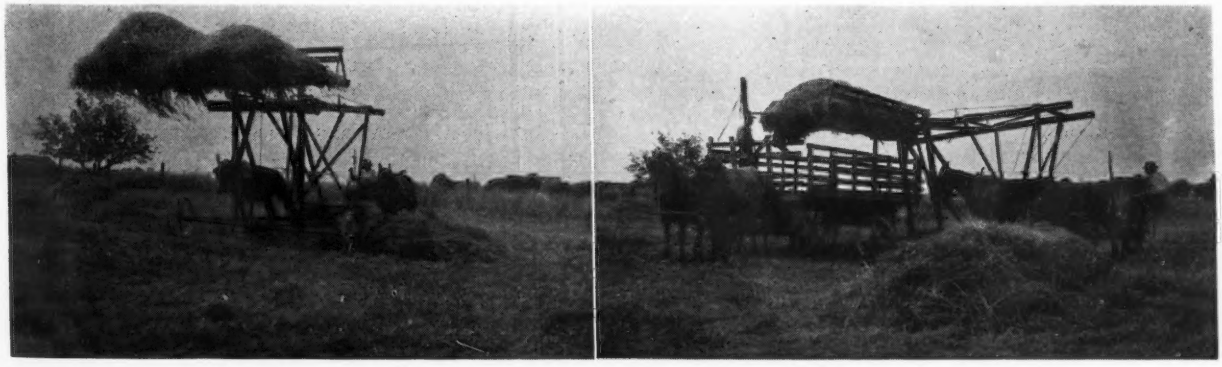
Raking, Bunching and Windrowing. The sulky, self-dump rake is the most popular machine for raking hay. In most of the northern and coast areas the hay is raked into windrows and put into shocks or cocks by hand. In most of these areas it is necessary to allow the hay to remain in the field for from five to ten days to properly cure it before stacking. It is necessary to have the cocks put up in good shape to protect the hay from the coast fogs or mountain showers. By properly cocking the hay from the windrows, time is saved in loading in that the cocks are made fairly small so that they can be lifted intact by a single field pitcher. In a few of the interior valleys in the northern section the side-

[1] A contribution to the symposium on haymaking methods and equipment presented at the Power and Machinery Session of the 22nd annual meeting of the American Society of Agricultural Engineers, at Washington, D. C., June, 1928.

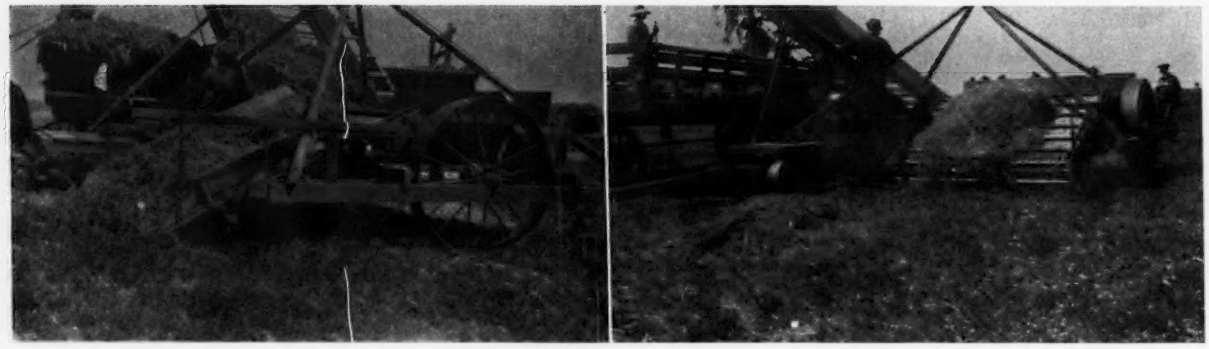
[2] Division of agricultural engineering, University of California. Mem. A.S.A.E.

[3] G. W. Hendry, Bulletin 394, "Cereal Hay in California."

[4] E. B. Cushman, Cushman Machine Co., Riverside, Calif.



(Left) A buck rake type of loader-stacker transporting its load to a wagon or stack. (Right) The same type of equipment loading a hay rack



(Left) Picking up hay with a windrow, cock or shock loader. (Right) A front view of the loader. In this case a tractor is used to pull the loader and wagon

delivery rake and hay loaders are used. This, for the main part, is on the native grasses, some of which are irrigated by the flood system. The fields are nearly level and free from ditches and irrigation checks. Raking of hay in the interior valleys and southern sections is done principally by the sulky, self-dump rake, part of which is rake-bunched. In the event the crop has been allowed to dry beyond the wilting point so that the leaves are brittle, the hand-cocking method is resorted to. The cocks are larger in size than in the northern sections and are allowed to remain in the field for from one to three days. Color seems to be an important factor in marketing alfalfa, especially in Los Angeles where a considerable quantity is used for rabbit and chicken feed.

Curing. The time for curing the hay varies from one to ten days, depending on the locality and type. The native grasses in the northern and coast sections require a longer field drying period, while alfalfa hay in such interior valleys as the Antelope and the Imperial may be baled or stacked a day or two after cutting.

Curing sheds have been established to a limited extent in some of the southern areas. These sheds are covered and are approximately 100 ft. wide and 500 to 600 ft. long. They are generally in conjunction with alfalfa meal mills. The floors in some cases are of concrete in order to save the leaves that are lost from the hay through handling. In the central and northern sections where curing sheds are used, poles are generally laid on the floor or ground to allow air currents to pass under the hay. The hay is generally piled from 2 to 3 ft. deep by means of a cable fork or swinging derrick. After it has been allowed to dry for 24 to 36 hr., an additional layer is placed on top. When the hay is to be used for alfalfa leaf meal, it is put through the mill as soon as the leaves are brittle. This practice is carried on to a limited extent in the state at the present time.

Loading. The major part of the hay crop is still loaded by hand in the northern and coast sections. Most of this hay is handled by a crew of two field pitchers and a loader. This comprises what is known as a three-man crew, the loader running the fork at the stack and the pitchers caring for the handling of the team while unloading and the mowing of the hay.

In a few instances more modern methods of loading hay have been employed in the larger fields. The shock or hay loader is used to either pick the hay from windrows or cocks. This type of loader is somewhat different from the hay loader used in the east. It is operated by three horses or a small tractor and loads the hay from the side of the wagon. The cost of this loader will vary from $1200 to $1400. It is capable of handling from forty-five to fifty-ton loads per day. The number of wagons necessary depends on the length of haul. The machine is approximately 15 ft. wide, which makes it rather inconvenient to transfer over some roads and bridges. The pick-up feature of the loader consists of three bars carrying special fingers mounted on an eccentric shaft revolving within a chain drag, which carries the hay to the main drag or draper. These fingers go under the hay, lifting it onto the carrier with very little shattering. Due to the eccentric feature, the fingers are dropped away from the hay through a comb which is used as a carriage and cleaner. This device can also be used for picking up and loading grain and beans.

The inclined plane system of wagon loading and stacking adapts itself very conveniently to power farming. The principal part of the hay loading device is an inclined plane having a width of approximately the wagon rack length. The length of the plane is approximately 25 ft. The sides are equipped with sloping guards with an apron at the bottom hinged to facilitate moving. The unit is placed on skids and transported by means of a small tractor. The operating unit for loading consists of a plunger with a perpendicular rack in front to hold the hay. The front end of the plunger slides on the ground while the rear is carried on small wheels. A tongue is placed on the rear of the plunger to afford a horse or tractor hitch. When horses are used, the hitch is swiveled so the team can be turned to pull the plunger down to its loading position. The tractor used for moving the plane can be used more conveniently for loading since less time is lost in returning the plunger. The hay is brought to the loader by a sweep or buck rake and deposited on the ground between the plunger and the incline. The rake load is usually pushed on the incline and the plunger returned for a second load. Where wind is to be contended with in loading hay, the incline is usually filled to accommodate a full load before being pushed into the rack. This prevents the loss of wind-blown hay since the entire load is put on with one stroke of the plunger. This equipment is generally homemade, in some instances being made entirely from pine or cedar poles.

The combination stacker and loader is used to a limited extent. This machine will pick the hay from the cock, transfer it a limited distance, and in so doing lift the hay to an elevation to be dumped on the wagon or stack. When used in irrigated alfalfa, it is desirable to operate within the checks to avoid crossing levees. This equipment is generally operated by two horses and a man, the horses being spread to work from the sides pushing the load, somewhat similar to that of the buck rake. The operator controls the lifting and dumping from a seat in the rear.

Hauling. The basket rack is the most common form of hay hauling equipment at the present time, although where green hay is hauled directly from the mower to be fed in the dairy the truck is playing a very prominent part. The truck is used almost altogether for hauling baled hay from the field to market. When the hay is hauled from the field to either a press or for stacking, trucks or tractors are used to haul the trailer or wagons, two to four in number. In the southern sections practically all of the marketable hay is baled and hauled with trucks and trailers from the field to market. These loads are placed in the afternoon and the trip is made at night to avoid traffic congestion. During the haying season it is not uncommon to see from sixteen to twenty truck and trailer loads going from the southern interior valleys to Los Angeles. This is practically all alfalfa hay to be used for either dairy, rabbit or poultry feed.

Stacking. A very limited amount of hay is placed on the stack by hand. Even the more remote districts in the mountains use some means of animal or mechanical power to place the hay on the stack from the wagon. In the areas in which the winters are more severe the majority of the hay is placed in barns or under an open shed. These sheds consist of the main section with a roof supported by poles with lean-to on two sides and an end. The equipment used for unloading is either a cable derrick or a hay fork and track permanently installed. In some instances where the shed is open on both ends a swinging derrick is used to stack from either end. In areas where the hay can be comfortably fed out of doors, the swinging derrick seems to have preference. This derrick is in most cases made of poles having an upright in the center, supported at the base, so that it is free to pivot and swing a boom over the stack. The boom pole in most cases is adjustable and carries a swing of 8 to 12 ft. from the vertical swivel pole. The stacker is placed on skids so that it can be easily transported. Where a long boom is used the stacker is staked to prevent its tipping when used at its maximum swing. The Johnson fork is very popular, although the sling is used to a certain extent in the higher regions where the native hay is very short. In some instances the derrick is equipped with a fork similar to that of the buck rake so that the entire load can be deposited on the stack at once.

The gin or single pole is used to a limited extent. It is generally equipped with a Johnson fork and supported by three guy wires. The tripod is practically obsolete in the northern and coast sections, although it is used some in the south.

The cable stacker meets with considerable favor where the temporary type of hay shed is used, the poles of the cable stacker being placed on either end of the shed and the cable strung through. This provides a means of stacking hay under temporary sheds without danger of wrecking the structure. In a very few instances the cable stacker is used for a temporary frame for stack covering. Old tarpaulins or boards are placed over the cable and additional guy lines strung between the poles to hold the temporary roof from the sides of the stack.

The majority of the hay stacked in the south is handled either by the cable or swinging derrick. In a few instances the overshot stacker is used. Since a large percentage of the marketable hay in the south is sold on the Los Angeles market, hay stacking has been considerably reduced while baling is increasing.

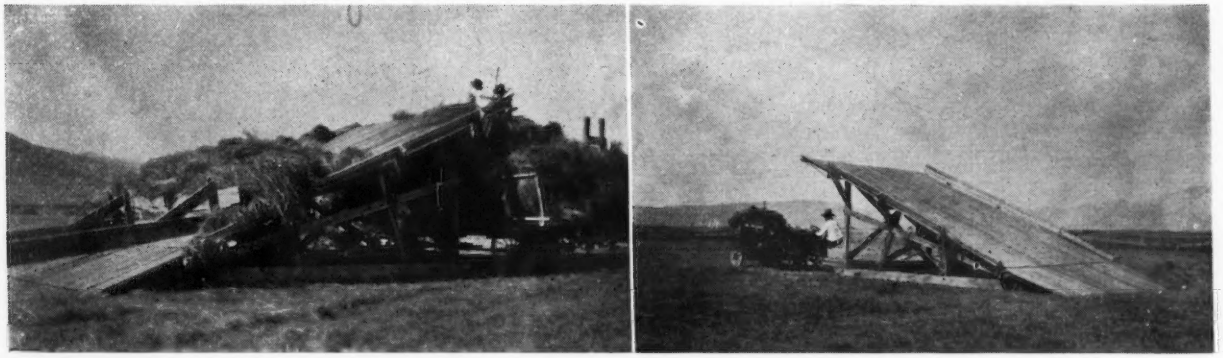
A few ranchers have adopted a system of chopping the hay and storing it in silos for dairy cattle feed. The hay is chopped with an ensilage cutter or hammer mill and blown into the silo. If the silo is to be left open, it is quite important to have the hay cured sufficiently to avoid heating.

Baling. The majority of the hay entering the marine export trade is compressed. The bales are reduced in volume by taking the hay from the original bale, running it over revolving cylinders to loosen it, and then being fed back into the compress. The compressed bale contains about 6 cu. ft. and varies from 50 to 70 cu. ft. per ton. This system is also used to blend hays, mixing the various grades or kinds for certain uses. Small quantities are sent to the Hawaiian and Philippine Islands.

The more common system of baling in the field is to use the buck or sweep rake to bring the hay to the baler and push it up an incline on a table level with the baler feed. This system is practiced throughout the state. Usually two or three buck rakes are used to serve the baler. After the haul becomes too great for the rakes, the baler is moved to a new location. The bales are stacked in the field and either hauled to the farmstead or market for storage.

The more recent system which is employed in baling, which is practiced to a considerable extent in the south, is to haul the baler through the field pitching the hay directly from the cock on to a feed table. This system is used most extensively in the Antelope and Imperial Valleys. The bales are picked up by the truck hauler in the field or, in some cases, are hauled on a skid to the roadside by a team or tractor. In the event the alfalfa is to be irrigated before the bales are removed from the field they are placed on the checks. In some instances the baler operates close to the check so that the bale is automatically deposited on the higher ground. Baling in these districts usually takes place from one to two days after the hay is cut. The baler operates only through the early morning hours. Some outfits are equipped with lights so that the crew starts working as soon as the hay has secured enough moisture to prevent the leaves from being brittle and falling off in handling. In most cases this operation starts about 3:00 a.m. and is continued until 10:00 to 11:00 a.m. The native hays are either baled directly from the field or from the stack after the hay harvest. The power for the more modern field baling units is furnished by a tractor which is connected to the baler so that it affords transportation as well as power for its operation.

A recent practice in the Imperial Valley, which is at present somewhat limited, is to pick the hay from the windrow by means of a hay loader which is attached to the side of a baler, depositing it on a feed table from which it is fed to the baler by hand. The trailer is attached to the opposite side of the baler and receives the bale. The entire unit is operated by a tractor and three or four men. Where the crop is light the crew consists of a tractor driver, a feeder, and a tier and loader. By this system the hay is picked from the windrow, run through the baler and placed on the wagon by mechanical power. In some instances a small scale is placed on the fore part of the wagon and the bales weighed and marked as they leave the baler. When the wagon is loaded it is dropped and another one attached. This system lends itself very readily to fully utilizing mechanical power, increasing the output in tons per day and decreasing the man-hours. In some sections where straw is used for feed and bedding the baler is attached to the rear of the combine.



(Left) In this view the plunger is moving a buck-rake load of hay up the inclined plane loader-stacker. (Right) A tractor is used to move the inclined plane hay loader-stacker

The Air Curing System of Making Hay[1]

By J. L. Adams[2]

WHILE hay ranks second only to corn in crop value, yet there has been less advancement made in hay making and haymaking machinery than in any other branch of agriculture. I believe this has been largely due to the fact that farmers in general have given less attention to the hay crop than to any other crop. Therefore, there has been less demand for improved hay machinery.

The farmers have sustained a greater loss by improperly handling their hay than in any other crop they raise. The evolution of hay machinery has been very slow with only three machines for cutting: First the sickle; then the scythe; then the mower. In rakes, the evolution covers the hand rake, the wooden revolving rake, and the sulky rake.

When be abandoned the wooden revolving rake for the sulky we went a step backward, because the former slipped the teeth under the hay and carried it much the same as the bull or sweep rake of today, while the sulky dragged it and also gathered trash and dirt. The windrows were more compact too when made with the sulky rake; therefore, the air did not have a free circulation through the windrows. Quality hay was sacrificed for a seat to sit on.

The tedder came next. This machine may have had its place in the evolution of hay machinery, for at that time no one had thought of designing a machine to care for the hay with the idea of saving the leaves, not knowing the real value of the leaves of the hay plant; in fact, it is less than sixteen years ago that the first attempt to design and build such a machine was made by the manufacturers.

We began to study the plant and realize that the farmers were losing food and money through the loss of so many leaves. By consulting with the agricultural colleges we found that over 65 per cent of the protein in legumes, especially alfalfa, is in the leaves and that approximately 80 per cent of the fat is in the leaves. Therefore, more than 70 per cent of the total food value in alfalfa is in the leaves. We also learned through the agricultural colleges that the circulation of the water through the plant while growing is very rapid, that it averages six to twelve or fourteen inches per minute. It takes approximately 400 tons of water to mature one ton of dry hay, and the average length of time between cuttings is less than thirty-five days.

While the plant is growing, the leaves are always on top; it matters not what condition the hay is in. If the hay stands up straight, the leaves are on top, or if it is lodged down, the leaves immediately turn up seeking light and air. When you sever the stems with the mower, the leaves are still on top. If the hay stands up straight when cut it falls back over the cutter bar just like the shingles on a roof, with the leaves on top and the stems underneath next to the cool moist ground. If the hay is badly lodged, you can scarcely tell where the cutter bar ran. By severing the stem you have destroyed the source of moisture for the plant, therefore, you have destroyed nature. The leaf of the hay plant is very thin and if allowed to lie in the swath any length of time it will crinkle up, and when it does no more moisture can pass through.

After studying this situation very thoroughly we decided that, if we were to save the leaves and maintain the color, we must protect the leaves soon after cutting in order to assist nature just as much as possible. The moisture must continue to come up through the stem and go out through the leaf until the moisture has been reduced to a point where it is safe to store the hay.

After a careful study we decided we would build a left-hand side-delivery rake. Up to this time everybody had been building a right-hand side rake. The mower cuts to the right and in order to properly cure the hay, it must all be moved. If we were to cover the leaves and put them inside the windrow, we must drive in the same direction while raking as we did while mowing, consequently we would have to throw the hay to the left. Another thing we knew we must do was to so construct the machine that the windrows would be loose and fluffy allowing a free circulation of air, so that when the leaves were throwing off the moisture by transpiration, the wind would blow the moisture away. With these things in mind we started to perfect a machine to do these necessary things.

The machine had to be so constructed that the capacity would increase as the hay moved toward the outer end of the reel. The capacity was increased in the same ratio that the volume of hay was increased, leaving the hay just as loose when it left the reel as when it started. We had to construct the teeth of the machine so they would lift the hay and not sweep it, and the teeth at the front end of the reel must let loose first. They would raise the hay, and as they passed back through the stripper bars the hay hit the stripper bars and was pushed over much the same as the dirt is turned by the moldboard of a plow. In this way in heavy hay we hide between 85 and 95 per cent of the leaves, putting them inside where they will not burn. In fact, nothing will burn so long as there is a circulation of moisture through it.

We had to take into consideration the question of rain. If rain comes after the hay is in the windrow, let it lie until the sun comes out. Then when the hay is dry on top and the ground beside the windrow is dry, we use an adjustment on the machine and set the left-hand main wheel in, and drive right along beside the windrow, going in the same direction we went in making the windrow and turn the hay just half way over, the dry hay on dry ground and wet side up. If the machine is properly adjusted the windrow should be at least twice as large as it was when it was first made, because the hay having once been moved, you can set the

[1]A contribution to the symposium of haymaking methods and equipment presented at the Power and Machinery Session of the 22nd annual meeting of the American Society of Agricultural Engineers, at Washington, D. C., June, 1928.

[2]Dain Manufacturing Co.

(Left) A left-hand side-delivery rake rolling hay into a windrow with the leaves mostly inside. (Right) Mowers cut to the right. This fact lead to the development of the left-hand side-delivery rake

teeth further forward lifting the hay still higher. We recommend when hay is heavy that the windrow always be turned, because the hay will cure more uniformly and faster.

We have made many tests trying to determine just how long the hay should lie in the swath and we have found that, when we rake almost immediately after cutting, we produce a higher quality and a brighter hay than when we allow the hay to lie in the swath from three to six hours and thoroughly wilt, although the tests show that we can get the hay into the barn a little sooner by letting it wilt thoroughly before raking. These tests also show that in handling the hay after it had lain in the swath from five to six hours, we lost a great many more leaves by shattering. Making hay in this manner was tried out very extensively by Profs. Hudson and McGee of Michigan State College.

This system, which we call nature's way, has been demonstrated at most of the principal agricultural colleges, especially those in the large hay growing districts, and has received very favorable comments.

Many of the large hay buyers advocate this system, and if you will watch the hay markets, you will find that nice pea green alfalfa with a large percentage of the foliage on it, brings all the way from six to twelve dollars more per ton than hay made under the old system, and there is always a demand for high grade hay.

This system works well in cow peas, soybeans, sweet clover, and in fact all other legumes. We strongly recommend air curing hay instead of sun drying.

An Investigation Into the Possibility of Improved Methods for Handling Hay[1]

By F. W. Duffee[2]

THE purpose of this paper is to describe the efforts being made at the University of Wisconsin in the direction of improved methods and equipment for handling hay. The method outlined here involves the handling of hay as cut, dried and raked in the usual way. The variation from present practices starts with the picking up of the dry hay from the swath or windrow, preferably the windrow.

The field machine will pick up the windrowed hay and feed it directly into a large cylinder-type ensilage cutter driven either by an engine mounted on the frame of the machine, or possibly, on smaller sizes, from the power take-off of the tractor. This machine will be equipped either with a carrier, or a small fan and an elevator pipe with a dust collector on the end of the elevator pipe. The chopped hay will be discharged into a tight wagon box of sufficient size to hold a normal load.

The hay is unloaded at the barn by sliding the load out of the rear end in a fashion somewhat similar to a manure spreader, permitting it to drop on a carrier which carries it into a fan which will elevate it into the hay mow, similar in principle to the Ronning ensilage harvester fan.

The aims and objects of this method, given in the order of importance according to our original ideas, although present developments tend to indicate that this may not be the correct order of importance, are as follows:

1. To reduce the labor required to put up a given quantity of hay at least one-third. (It is hoped we will reduce it one-half.)
2. To eliminate all the hard work of putting up hay
3. To produce a product of higher feeding value
4. To reduce the storage space required
5. To make easier handling in the mow.

It is thought that hay put up in this way can be put up just as soon as hay put up whole. In fact, there is a very small amount of evidence to indicate that it can safely be put up just a little bit wetter or greener.

We believe it will be possible to build a machine of sufficient capacity so that one man can load the wagons at an average rate of three tons per hour, and we believe it is possible to develop the equipment to the point where one man can do this alone from the seat of the tractor which is pulling the machine.

At the barn it will be possible, we believe, for one man alone to unload it at least at an equal if not faster rate, and his task will merely consist of turning the crank that slides the load out of the rear end, a job which can be done very easily by a twelve-year-old boy according to the experience which we had last summer.

In view of the greater density of this cut hay it should be more readily possible to haul somewhat larger loads, thus reducing somewhat the time required in hauling. Except, however, for this slight advantage the labor in hauling would remain approximately the same as at present. Theoretically, the above changes should show a very appreciable saving in labor according to data available at the present time on the rate of loading and unloading by present methods in vogue in this part of the country where hay is stored in the barn.

Theoretically, there is no work in connection with this process of making hay where a 12 or 14-year-old boy would not be easily able to do just as much work all day long as a strong man. Probably the most difficult job would be the hitching up of an empty wagon to the machine in the field. Otherwise the work consists of driving the tractor; driving team or tractor in hauling; and unloading at the barn, which we feel very sure can be so designed as to be very easily accomplished. In fact, it would not be impossible to arrange the unloading so that there would be practically no work at all involved; or it might be possible to use the dump trucks.

Numerous experiment station tests from all over the country demonstrate at least slight increases in feeding value of chaffed or chopped hay. Cut or chaffed hay invariably shows a somewhat higher feeding value, the increase in feeding value depending somewhat upon the class of stock to which it is fed and to a larger extent upon the quality of the original product. The gains are usually greater with a coarser and lower grade hay.

In our work last summer we used a cylinder cutter adjusted for the ½-in. cut but did not use a recutting screen or a recutting mechanism of any kind. This, of course, meant that very little of the material was cut as short as ½ in. Much of it was as long as 2 or 3 in. We expect this year to use approximately ½-in. cut on the cylinder and use a 1-in. perforated recutting screen.

Bulk hay ordinarily requires from 400 to 500 cu. ft. per ton. The coarsely chopped hay which we cut last summer required about 290 cu. ft. per ton. In a recent test a good grade of alfalfa hay run through a cutter set at about ⅜-in. cut with a ½-in. perforated recutting screen required 136 cu. ft. per ton, being more dense than it was in the bale form. This test was made about the first of April and the hay was, of course, thoroughly dried. We expect that the hay which comes from the machine, cut as mentioned above, will probably run from 200 to 225 cu. ft. per ton, thus approximately cutting in two the storage space required for a given amount of hay.

Hay chaffed in this manner can be very easily removed from the mow by the use of an ensilage fork. It can be taken out much more easily than bulk hay, and, due to its

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[2]Associate professor of agricultural engineering, University of Wisconsin. Mem. A.S.A.E.

greater density, almost as large a quantity can be carried on an ensilage fork as is ordinarily carried.

The hay which we put up by this method this last year was carefully observed and kept equally as well as the hay which was cut and taken up at exactly the same time and put away in the regular form. One man who has practiced cutting the hay as it comes from the field and blowing it in to the barn, claims that he has had experience indicating that hay can be put up a trifle wetter and greener by this method. However, we do not know what kind of hay he was putting up or whether the climatic conditions under which he was operating are near enough the same as those in Wisconsin to warrant drawing any conclusions from his experience.

We anticipate that approximately 25 hp. will be required to operate the field cutter. This is probably somewhat less than past experience would indicate is required. However, the hay coming up from the windrow gives almost an ideal feed to the machine and we believe this will mean that a somewhat greater quantity of material can be put through with a certain amount of power than where either mowed, stacked or baled hay is fed into the machine.

We have conducted tests on the recutter set for about ⅜-in. cut using a ½-in. perforated recutting screen where around 11 to 12 hp.-hr. per ton are required. On the basis of this, and with more uniform feed, we estimate that 8 hp. per ton per hour will suffice for our conditions. This is further borne out by the experience of last year where we used an 8-hp. engine on the feed cutter. We were able to cut about a ton an hour with this machine, and it was not operated under anywhere near ideal conditions.

It is hard to say at this time as to how expensive the equipment required by this method will be, as we do not know just how simple or elaborate certain parts will have to be to function smoothly. However, we can say that the equipment will displace the use of hay loaders and present barn hay handling equipment. The construction of a wagon designed for this work need not be at all expensive. A 7x14-ft. hay rack with sides about 4 ft. deep will hold a normal load. An 8x16-ft. rack about 3 to 3½ ft. deep will hold a normal load. This, of course, depends to a large extent on how fine the hay is cut.

We have had enough experience with this system so far to indicate that it has distinct possibilities. However, we have found that there are also some rather difficult problems to be overcome in the development of the machinery.

Discussion on Hay Making Methods

ONE of the features of the symposium on hay making methods at the power and machinery session of the 22nd annual meeting of American Society of Agricultural Engineers at Washington in June was an extemporaneous talk by Edward C. Parker, senior marketing specialist in the hay, seed, and feed division of the U. S. D. A. Bureau of Agricultural Economics. Mr. Parker's remarks consisted largely of a request that the agricultural engineers in their research problems gives consideration to the matter of quality in hay, as well as to such items as cost of production, rapidity of harvesting, etc. He pointed out that certain labor-saving devices, which might effect a saving of one or two dollars per ton in cost of production, might, at the same time, cause a loss of a greater sum in lowered feed value.

In the discussion that followed Mr. Parker's talk, the question was raised of curing hay where rainfall is excessive by the use of racks. This practice is followed in Kentucky and Louisiana and has the advantage of providing air circulation from below after rains occur. In reply it was also pointed out that most of the peavine hay in Georgia is cured by this method. The hay must dry slightly before being put on the racks. Hay is often saved from spoiling by using this method rather than leaving it in contact with the ground as is done when the sulky rake is used.

The question was asked about the effect of the 1½-ton stack on a second crop of hay. In answer to this question Mr. Parker stated that no observations had been made by him personally on this but that he had learned that the damage was not serious. He stated that the area covered by these stacks was relatively small, being only a few square feet to the acre.

In answer to the question as to what stage of curing the hay was put in the stack, it was stated that the hay was cured in the windrow to about 35 per cent moisture content; the hay contained about 70 per cent moisture when cut. The moisture content was not obtained from actual test, but was concluded on the basis of color and the general condition of the hay as observed. The hay was swath dried for three to six hours, after which a side-delivery rake was used. It was stated that two methods were very often employed in the use of the side-delivery rake: First, raking shortly after mowing, and, second, swath drying from two to five hours. Raking immediately after mowing was thought to be a bit dangerous, but a slight drying was known to be safe.

In answer to the question as to what the advantages of the sweating process in hay making were, Mr. Parker replied that the hay was rendered more palatable and aroma was added. The sweating process also produces clinging foliage.

A question was asked as to the effect of long wheat stubble left in the field by a combine on the quality of hay produced, inasmuch as in tall grain a stubble of 20 to 24 inches is some times left when a combine is used. The answer to this was that the first cutting of hay would contain 10 to 15 per cent straw and that the grade would be lowered accordingly.

Mention was made of the work done by agronomists to develop the quality of non-shattering in wheat and oats, especially in connection with combine operation, and the question was raised as to whether anything had been done to produce strains of alfalfa which would be resistant to leaf shattering. A scientist of the U.S.D.A. Bureau of Plant Industry replied to this question by saying that nothing had been done in this direction and he did not think it would be possible to accomplish anything.

Attention was called to the instance of a farmer discontinuing the practice of raking hay immediately after mowing. In this connection it was pointed out that no difference was usually observed in raking immediately after the mower or a few hours later in moist weather. Much larger loss of leaves, however, occurred when hay was allowed to lie in the swath for six hours. The main reason for swath drying was to shorten the time of curing, but quality was often sacrificed for speed when swath drying was practiced.

As to the difference in raking hay in the forenoon or in the afternoon, it was pointed out that raking should be done preferably in the morning when the dew was all off the ground. It was also pointed out that no definite time limit could be set for raking after mowing, but that the condition of the hay must determine the best time of raking. It was pointed out that in no case should hay lie in the swath until the leaves have shriveled up.

Asked whether there was any definite time required for the sweating process, Mr. Parker answered that no definite time could be set as it depended on the size of the stack.

The discussion brought out the fact that nothing definite is known as yet as to the effect of artificial curing on the quality of hay.

Answering an inquiry as to the best time for cutting alfalfa hay, Mr. Parker stated that from the quality standpoint alone alfalfa hay should be cut in the bud stage. But this is hard on the vitality of the plant and cutting at about one-quarter of the bloom stage was advisable although it does not yield the best quality of hay.

In connection with the question of the feeding value of cut hay vs. uncut hay, doubt was expressed as to the economy of cutting hay. It was pointed out, however, that in steer feeding investigations conducted at the Idaho Agricultural Experiment Station it was found that greater gains were made on cut hay and that the gain was about proportional to the cost of cutting.

Developing the Rural Electric Business[1]

By C. P. Wagner[2]

PRIOR to going into this subject, we want to inform you, as we have been informed in the past, that we do not yet have a complete solution to this problem. Our territory is, and the conditions under which we must sell the idea are, like California weather—very unusual. We have yet to experience the first occasion at which others have not informed us that we operate under methods and obtain results in our territory which could not be obtained in theirs. This indicates to me that the development of the business by various companies is not consistent and that insufficient study of the problem has resulted in each breaking off into a different line of attack.

Our executives have attacked the problem, worked out the preliminaries and then turned it over to us with the thought that we must sink or swim with the tide. It is now up to the rural service men to work the final details into operating conditions and to put into effect the best plans available. Perhaps we ourselves are each sold on the idea of our own method to the exclusion of the methods of others. We need an organization and sectional group meetings where we can learn from each other. Some of us are poorly informed on many questions which could be worked out by cooperation.

Many groups are tied up with our development program and we feel that the major selling job in the early stages is not necessarily with the farmer, but with advisory groups, such as,

1. The associate engineering groups in this Society
2. Groups with which these engineers are closely attached
3. Manufacturer's groups
4. Jobbers and their salesmen
5. Local dealers in implements and equipment.

Through selling the idea generally, we will find that in the end our own development will be more rapid and that less gears will strip as a result of our preeducational plan. Vast enterprises feel that the entire problem rests with the power company and dozens of manufacturers' representatives call at the power company office and request that their product be sold by the power company to the farmers.

Why not develop our plan and then say, "There is the field—you can sell your product?" Are we too jealous of our present plans and too afraid to permit others tc enter the field and sell equipment?

I feel that, at the present time, the farm service engineers must use a major portion of their time to sell the idea to other principal parties who should be interested and who will profit from the development of this business. Farm schools are to a certain degree trying to sell the idea to manufacturers of apparatus, but the closing of the sale must be made by the power companies. Individual dealers in equipment of all kinds, wire men, even hardware men must be sufficiently sold on the idea to be able to see clearly the problem and give aid when it is needed. Without the aid of this class of dealer and party, who is in contact daily with the farmer, we will find hard sledding. Unavoidably, if these people are left uninformed, they will do considerable injury and advise against work which is recommended by the power engineer. Take electric wiring for example. Many power companies jumped on to the one meter electric rate for the farmer and we believe rightly, because of the fact that the farmer does not understand the reason for charging different amounts for electricity used for different purposes. The rate can, with proper study, be properly applied to the average uses for all classes of work on the farm in such manner as to give the power company adequate returns. But such a rate, especially when there is a low encouragement stopping after not more than 70 to 80 kw-hr., requires a much larger capacity wiring system for prospective than for immediate load. Preliminary sections of the wiring system must be of sufficient capacity to carry the ultimate load in view, not the farmer's view but the engineer's view. When recommendations are made it is easy for the farmer to go into town to associated workmen and sales people and obtain advice that the requirements are beyond reason, unless a prior effort is made to sell such parties on what is to be attempted. We need every effort to sell the idea of future development and to maintain thorough satisfaction after the sale is completed.

We have yet to find a gathering where the discussion did not ultimately work back to rates. We, therefore, would leave this question out, excepting that we believe the larger companies should provide a rate which will let them serve, or at least make a definite proposition to any individual alone, regardless of his distance or the total investment. The rate should be in the form of investment required or minimum bill or service charge for any distance. Such rates will create much better public relations and throw the responsibility for uneconomic lines onto the community, as always if the rates are correct. The economic problem will be one for the farmer as an individual, or a group, rather than for the power company. The farmer knows his rods, quarters and sections, but when he wants a power line, he usually has very short miles and he wants his line right away.

Selling the idea to the executives of the power company is not always an easy job, even though they have hired us for the job of selling to the farmer. One particular new man taken onto a job to handle the development of electricity on the farm, wrote us a letter asking a large number of questions about what we would do if we had to start new on the work, or in a new company. We had quite a time planning what we should tell the poor fellow, but finally we informed him that the best and first thing to do was to find whether his executives were really sold on the idea, or whether they were merely hiring him because it had become popular to have a farm service man. We believe that the man taking over a job in a new company must be prepared to be disappointed many times, and such a man must have the initiative to go up and place each point clearly on the table and fight for a decision in accordance with his ideas. He, of course, must have ideas which are sound. Our largest consumer, recently connected, will probably go 30,000 kw-hr. for 1928, but the connection required two miles of line, and if we had not been thoroughly informed and ready to go to the top for decisions, we fear that even that good consumer would not have had a line in 1928.

The farm service man must, above all else, be thoroughly informed on the economics involved, or he will not be of value to either the farmer or his company. One other question asked by the above mentioned new man was, "If new territory is unable to finance a line and such lines are unprofitable for the power company to finance, how would you advise development of the construction?" Our answer was that if such communities were developed, that there would be only a short time alloted for the life of the operating company and the supervising farm service men. We must produce a sound and economic situation in almost every case, both for the farmer and the power company, or we cannot be successful in handling the work.

As engineers shall we always go into the history of scientific research to prove our economies? I believe not. One large problem involved in connection with the use of power on the farm is the operation of roughage mills. We find that in practically no case will the animal husbandry man inform us that these machines will develop economy in feeding the dairy herd. Many farmers are being sold such machines, however, and due to the fact that they must be used often, because of the possibility of feed spoilage, the electric motor, starting at the touch of the button, proves an ideal drive. I feel that the power company man should not be

[1]Paper presented at a meeting of the North Central Section of the American Society of Agricultural Engineers, at Ames, Iowa, May, 1928.

[2]Rural applications engineer, Northern States Power Company.

too well equipped with data as to the value of products, unless such data is positive. We must not always make recommendations as to whether or not to use certain machinery. If the machinery is in use, then we should provide data to show how to operate it within the capacity of the motors which we would like to operate on our lines. Of course if the engineer sees something which is vital, he might make inquiries and then inform the farmer as to what he has been advised and the source of such information.

The results of the work of a farm service engineer and his staff are unmistakable. Upon taking over the service in our company, we found our farmers using very small amounts of energy. In one district we had 272 farms connected and we would show the analysis of operation as follows:

Rates: Lighting—12 cents per kw-hr.—minimum bill $5.00 per month. Kw-hr. entitled to—42

Power—7 cents per kw-hr.—minimum bill $1.00 per horsepower. On bills up to $4.00 minimum, the power minimum was deducted from lighting minimum.

Average minimum—$6.20 per month

Average kw-hr. used per month—per consumer—31.

It is readily seen that these consumers did not use near their minimum.

The following are the results of two years operation under farm service department:

Changed rates to new form—60 of the better users, average per consumer for these 60 was increased 112 kw-hr. per month.

212 consumers left on old rate, analyzed as follows:

Average minimum bill $5.30
Average kw-hr. per month, increased to ..... .68
Average bill per month $7.20

Large numbers of these farmers now see the advantage of the newer rates and are either taking same at once, or are signing contracts effective next fall.

In one case, we acquired a small company with fourteen farms connected, and upon checking we found that these farms were charged a demand charge of $3.00 per month, called core loss charge and 20 cents per kw-hr. for energy. They used an average of 9 kw-hr. per month for a period covering three years. We changed their rates to service charge, $8.00, energy 30 kw-hr. at 5 cents, excess at 3 cents. These farms average 90 kw-hr. per month on this new rate for the first year and their new bill was $11.30 per month. Farmers are enthused about the low energy charge and will use the energy in large quantities when it is possible for them to obtain it.

In further analyzation of operation of the farm service department and rates which encourage uses of large quantities of energy, we would advise that our rural department's report for two years' operation showed data as follows:

	Per cent
One year ending June 1925, percentage of farms using more than 1000 kw-hr. per year.....	4
End of first year of farm service operation	21
End of second year of operation	44
End first year's operation, percentage of farmers using more than 2000 kw-hr. per year	6
End of second year of operation	19
End of second year of operation, percentage using more than 3000 kw-hr. per year	9

	Kw-hr. per-yr.
Largest user for year, previous to operation of department 4150	
End of first year, this same consumer jumped to...6170	
End of second year, all consumers using more than 3000 kw-hr. per year, average per year 6400	

Largest user at end of second year, connected only 9 months used 1080 kw-hr. per month.

Expected percentage, 1928, using more than 3000 kw-hr. per year—19 per cent

Our worst group, covering 72 farms in one section on high rate, $4.00 minimum and 15 cent energy, averaged 22 kw-hr. per month when farm service work started, and the first year they increased to 27 kw-hr. per month. The second year they jumped their average to 33 kw-hr. per month, or more than 30 per cent increase each year. We have reason to expect an increase of 50 per cent on this group in 1928.

Unquestionably there is now in development a new line of engineering, which is neither normal agricultural engineering, nor is it strictly power engineering. Work with the farmer causes the engineer handling same, to travel over large areas and to handle strictly farm service work, which will in most power companies cause duplication of both effort and travel. We believe, therefore, that the engineer handling this work should also handle power and electrical applications for all rural territory. Such an engineer therefore, becomes, strictly speaking, a rural electric service engineer.

We feel that in the large company, the rural department should be developed with a variety of specialists as regards their basic training; some mechanical engineers, to whom studies can be referred as to development of new machines and methods, some trained agricultural engineers to whom problems strictly agricultural may be referred, some electrical engineers capable of obtaining a more complete analysis of electrical problems alone. Not only these, but when opportunity warrants another man, we would advise training of one who has majored in animal husbandry work. If such an organization is developed and monthly conferences of the group held with each man handling his specialty, then the whole department can be welded into an organization of vast knowledge. Each man can be trained to handle the entire field work for a district, and his problems, which others in the organization may be better able to develop, can be referred to and studied at the conferences. Our specialty men handling franchises and street lighting, as well as other work requiring contact with village councils, find it very desirable to confer frequently with the rural service department, because of the interests of council members coinciding with the interests of the farmers.

Some manufacturers have started training courses for farm service men who will later go to power companies for work. These manufacturers are quite frank in stating that the men are being trained for work in power companies only, as they have no place for such men in their organization. We feel that they are badly misled, as the future in farm service work should not all be thrown on the power companies. Manufacturers and their jobbers should at this time recognize that they too must start specializing to reach a hitherto undeveloped field. A large feed grinder manufacturer has, up to the present time, been handling all work with men specialized in gas engine drive, and when we write them we find that their vice-president handles our correspondence and while their machines are tested on the floor with electric drive, they are unable to inform us as to the electric capacity or speed for any of their machinery. In consequence, in many cases, their machines are sold on our lines for electric drive under conditions which we cannot meet without considerable experimental work in the field. Why should this company not have a specialist handling this problem?

Jobbers selling machinery and motor equipment throughout the rural area, are peeved when the power company buys nationally and sells to the farmer, but these jobbers cannot sell such equipment without properly trained farm service engineers. Let us develop that idea with the national manufacturers and with jobbers in our territory. A few months spent with them will assist us to reach additional thousands of farmers more effectively in the future.

We have therefore pointed out that this specialized engineering service is invaluable, regardless of where it is located, but our group must organize for effectiveness. With what organization are we going to affiliate ourselves? We feel that the work of the agricultural engineer is going to be tied up irrevocably with the development of rural electrification. The major educational work with the farmer is through the agricultural colleges through which many of our agricultural engineers operate. Perhaps then the future can best be developed for farm electrification through an affiliation of the farm electric service specialists with this Society.

A Study of Substitute Fuels for Gas Engines[1]

By Primo R. Carreon[2]

IT MAY not be long before the world will have to grow its motor fuel rather than depend on oil wells. While it is true that the decay of vegetable and animal matter may be forming a new deposit of oil, it is generally agreed by geologists that the world is using the existing supply of mineral oils faster than the rate of deposition. It is viewed that alcohol may be the most promising substitute as a motor fuel and that it may be possible to produce an inexhaustable supply, for it could be manufactured from any crop which contains starch and sugar.

Other investigators have found that farm gas engines on the present American market could be run on alcohol and deliver more power than when petroleum distillates were used. The consumption of alcohol, however, per horsepower-hour was about one and one-half to two times as much as the consumption of petroleum distillates (13)[3].

Their results indicate that the method of using mixed fuels offers an important field of investigation during the transition period from using petroleum distillates to alcohol. The method of mixed fuels has the advantage of utilizing the full power of the engine and the plant already in use; besides it gives the engineer a period of grace to design efficient alcohol engines to replace ultimately the gas engines now in use. It has the further advantage of familiarizing manufacturers and owners with the use of alcohol as a fuel.

Alcohol Mixtures. Alcohol mixed with other substances has been used as a fuel with varying degrees of success since the World War. In Europe the mixture most used and favored by English and French authorities is 50 per cent of coal tar benzine with alcohol (9). In South Africa the fuel called "Natalite" which consists of about 54 per cent alcohol, 45 per cent ether, and 1 per cent trimethylomine came into wide use during the World War due to the high cost of gasoline. In Hawaii in 1918 a motor fuel very similar to Natalite was used very successfully in the place of gasoline. This mixture contained 55.55 per cent alcohol, 42.78 per cent ether, 1.11 per cent kerosene, and 0.56 per cent pyridine (4). It is claimed that the engine can be started on this mixture even more easily than with gasoline, which is due to the volatility of the ether. The mixture named "E.H.A." which contains 65 per cent alcohol, 10 per cent ether, and 25 per cent benzol has been used (7).

A solution of acetylene gas in alcohol has been suggested, but since acetylene is usually expensive it would not be practical except in places where acetylene is a cheap product. A solution of hydrogen in alcohol was tried but was not found very satisfactory (9).

Mixtures of alcohol and gasoline have been tried, but the alcohol used was absolute (200 proof) which can not at present be economically produced on a commercial basis. This mixture which has excellent starting and operating characteristics was found adaptable to airplane or other high compression engines (15).

Purpose and Limitations of Investigation. The work reported deals with the use of commercial alcohol (190 proof) mixed with either gasoline or kerosene as fuel for gas engines. The objects were to determine whether the gas engines at present on the American market could be run efficiently on alcohol mixed with either kerosene or gasoline as fuel, without any material modification of the engine; and to determine the possibility of modifying the existing type of gas engines so as to enable them to run more efficiently on these mixtures.

The author feels that, before reporting the results of this investigation, certain limitations should be called to the reader's attention. Only one gasoline, one kerosene and two engines were used. Almost all of the work was done by a single investigator, thus resulting in the maximum possibility of error of judgment and manipulation. However, the closeness of the check between different runs on the same engine, and runs on the two engines (See Figs. 4, 5 and 6) and the fact that this report is based on ninety-three

[1]Abstracted from a thesis for the degree of master of science, University of California. Prepared in the division of agricultural engineering under the direction of E. G. McKibben, assistant professor of agricultural engineering.

[2]On leave from the department of agricultural engineering, University of The Philippines.

[3]Numbers in parenthesis refer to the bibliography following this paper.

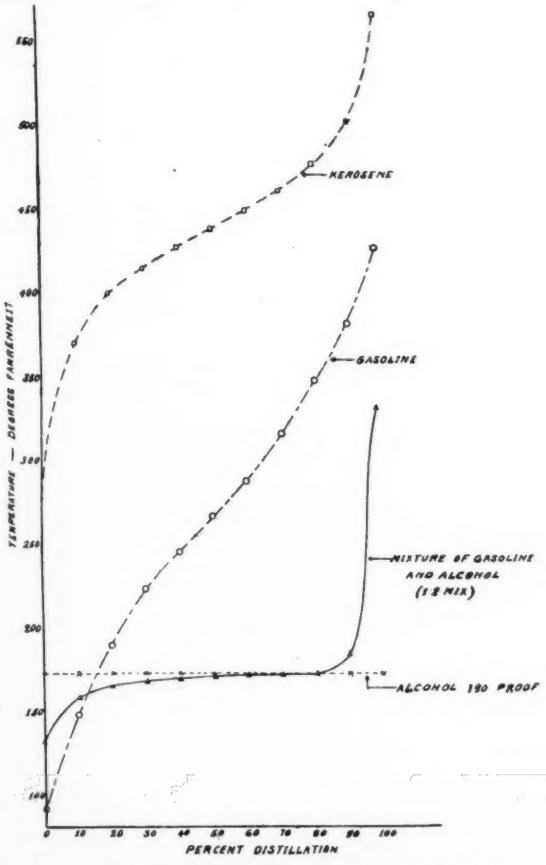

Fig. 1. Distillation curves of the fuel used

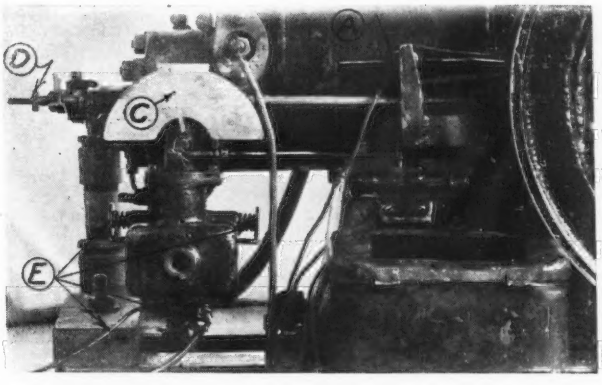

Fig. 2. View of Plant I. A, ignition adjustment; B, governor speed adjustment; C, throttle opening indicator; D, exhaust valve adjustment; E, two independent nozzles, needle valves and fuel lines

runs of one hour duration each, indicate that the results at least have qualitative if not quantitative value.

These results may not be directly applicable in the United States as the cost of gasoline and other petroleum distillates is so low that industrial alcohol can not very well be placed on the market in competition. In places like the Philippines, Cuba, Hawaii, Australia and others where the cost of petroleum distillates is greater, and where there are large potential sources of cheap alcohol, the practical application of the problem may be possible.

Test Fuels Used. (Note Fig. 1.) In order to describe the fuel used in this investigation the standard methods of distillation given in the U. S. Government Standard Specification No. 2, Technical Paper 323 A, published by the Department of the Interior, Bureau of Mines, were followed. The gasoline used in these tests had an initial boiling point of about 92 deg. F. with an end point of about 428 deg., while the kerosene had an initial boiling point of about 275 deg. with an end point of about 567 deg.

The alcohol used was distilled in the same manner as the petroleum distillate and was found to have a constant boiling point of about 173 deg.

In the mixture of gasoline and 190 proof alcohol with a ratio of one part gasoline to two parts alcohol, the initial boiling point was about 132 deg. with and end point of about 330 deg. It is known that ethyl alcohol with gasoline forms an azeotropic mixture of minimum boiling point, which has the greatest volatility at a definite composition of the mixture (14). From Fig. 1 it will be noted that the mean boiling point of the mixture is lower than the average of the sum of the mean boiling points of alcohol and gasoline alone. The ratio of 1:2 mixture is the maximum miscible mixture of this gasoline in 190 proof alcohol that could be attained at 70 deg. Other ratios used for this test are 1 to 5 and 1 to 10 gasoline to alcohol, respectively.

In case of the kerosene and 190 proof alcohol the different proportions of the mixture were attained by the use of two jet carburetors.

Conditions of Test. Two representative farm gas engines hereafter called Plant I and Plant II were used in this experiment.

Plant I had a 4 3/16-in. bore, 6-in. stroke, horizontal cylinder and was rated at 3 hp. at 375 r.p.m. (See Fig. 2.).

Plant II had a 4 ¾-in. bore, 8-in. stroke, horizontal cylinder with a closed crankcase and was rated at 6 hp. at 550 r.p.m.

The load in terms of torque was obtained by the use of a Prony brake. The same system of measuring load and speed was applied to both plants.

In the series of tests on Plant I, four compression ratios, 3.75, 4.38, 4.93 and 5.7 to 1 were used. These compression ratios were selected to practically cover the different compression ratios of some of the most common farm gas engines and tractors on the present market and were obtained by

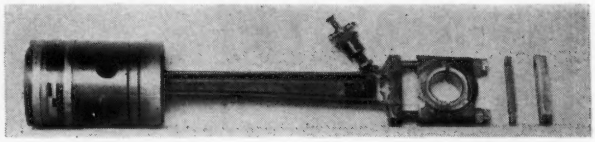

Fig. 3. The marine type of connecting rod and spacing blocks were used to obtain the different compression ratios

use of the marine type of connecting rod and spacing blocks shown in Fig. 3. In each series a constant load and speed were practically maintained. The fuel consumed was measured by weight from tanks of adequate capacity supported on a scale graduated to hundredths of a pound. Each test or run had a duration of one hour.

In each series of runs with the mixture of water and kerosene, the first run was made with kerosene with the least needle valve opening possible without detonation. In the second run the water needle valve was opened slightly and the kerosene needle valve was adjusted to the least possible opening without missing or detonation. Similar runs following the same procedure were made until the point of minimum kerosene consumption was reached, that is, the point where any increase in the water needle valve opening required an increase in the kerosene needle valve opening.

In the mixture of alcohol and kerosene similar adjustments were made until the engine was running on alcohol alone.

For all runs on Plant I the ignition timing was adjusted to give the best performance of the engine without missing and detonation. In Plant II compression ratio and ignition timing were used as provided by the company.

Ignition Timing. (Note Fig. 4.) Three series of tests were made on the ignition timing using three different loads, various proportions of kerosene and 190 proof alcohol and Plant I adjusted to a compression ratio of 4.38 to 1.

It was found on this particular plant that the ignition should be retarded from light load to heavy load in order to prevent detonation of the engine when adjusted for the least amount of fuel consumption. From the results shown in Fig. 4 the curves are almost similar, showing that ignition should be retarded from light to heavy load at different proportions of the mixture. It was also found with this plant that, to get the best results, ignition timing should be advanced as the percentage of alcohol is increased in the mixture of either kerosene or gasoline. The power, smoothness and sound of the engine were the factors that were considered in determining the right ignition.

Although mixtures of alcohol and petroleum distillates require the advancing of the ignition timing of this particular plant, yet the ignition of about fifty-fifty ratio of the mixture was approximately the same as in most farm gas engines. The increase is not large as compared to the increase required when alcohol alone is used.

It was also noted that, for most satisfactory performance

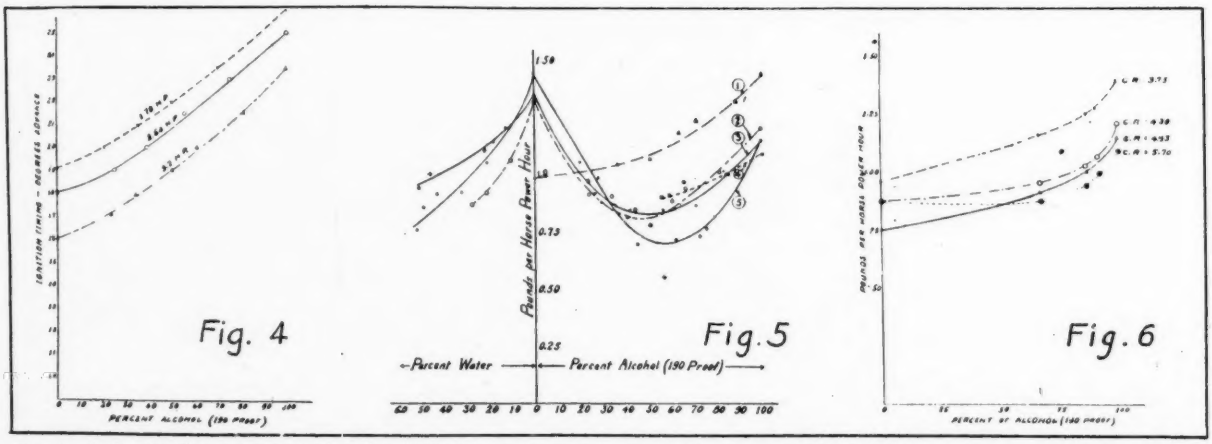

Fig. 4. (Left) Ignition curves of Plant I adjusted to a compression ratio of 4.38 to 1. Fig. 5. (Middle) Fuel consumption of Plant I at different proportions of mixture of water and kerosene, and of alcohol and kerosene at various compression ratios. Fig. 6. (Right) Fuel consumption of Plant I at different proportions of gasoline and alcohol at various compression ratios

with a given load, speed, and fuel, it was necessary to retard the spark as the compression ratio was increased.

Cooling of Engine. It was observed in this plant that the mixture of either kerosene or gasoline with alcohol evaporated less water from the cylinder jacket than either kerosene or gasoline when used alone. It seems to indicate that as the proportion of alcohol is increased less cooling water is needed to secure the best economy.

In the case of 5.7 to 1 compression ratio running water was used to cool the engine. The water entered the cylinder jacket at a temperature of 72 deg. F. and left at a temperature of 172 deg. This step was necessary to prevent preignition of the mixture and knocking of the engine, which was probably due to some hot spot such as the exhaust valve or spark plug joints which were not sufficiently cooled by the open jacket method.

Carbon Formation and Oil Dilution. Lack of time prevented a thorough investigation of the tendency of the various alcohol petroleum mixtures to deposit carbon in the combustion chamber and to dilute the crankcase oil. However, the brief study which was made of these phases of the problem seemed to indicate that there was less carbon formed and less dilution of the crankcase oil when using the mixtures than when using either gasoline or kerosene alone.

Fuel Consumption. (Note Figs. 5 and 6.) Tests for the fuel consumption of Plant I were made using the following compression ratios: 3.75, 4.38, 4.93 and 5.7 to 1. Note Curves 1, 2, 3, and 4 of Fig. 5. This figure gives a rather complete picture of the relationship between the compression ratios, fuel composition, and fuel consumption for both plants.

With the first initial compression ratio of 3.75 to 1, the total amount in pounds per horsepower-hours of all ratios of the mixture of alcohol (190 proof) and kerosene was greater than when kerosene was used as fuel alone, but less than the amount of alcohol when it was used alone. (See Curve 1 of Fig. 5.)

There was a marked decrease in alcohol consumption with the compression ratio of 4.38 to 1. The total amount per horsepower-hour of the mixtures ranging from about 31 to 63 per cent alcohol was less than the amount of kerosene when used alone or with water. (See Curve 2 of Fig. 4.) It is common practice to use water at this compression ratio, when running with kerosene, to prevent knocking and overheating of the engine. With this method a better economy of kerosene can be obtained.

When the compression ratio of 4.93 to 1 was used, a curve similar to that obtained with the compression ration of 4.38 to 1 was obtained. The total weight per horsepower-hour of the mixtures ranging from 27 to 75 per cent alcohol was less than the minimum amount of kerosene in the mixture of kerosene and water. (See Curve 3 of Fig. 5.)

The 5.7 to 1 compression ratio gave the least alcohol consumption. The mixture in this compression ratio is, however, higher than the 4.38 and 4.93 to 1 ratios. (See Curve 4 of Fig. 5.) With less than 55 per cent alcohol in the mixture of kerosene and alcohol the engine could not be run economically because of knocking due to detonation.

Plant II was operated on the same mixtures to check the above results. The results are shown in Curve 5 of Fig. 5. Note that Curve 5 in Fig. 5, for a compression ratio of 4.35 to 1, is quite similar to that obtained with a similar compression ratio to 4.38 to 1 (See Curve 2 of Fig. 5) with Plant I. Plant II showed a better economy. This may have been due to the larger size of Plant II as compared to Plant I.

Three proportions of the mixture of gasoline and 190 proof alcohol, that is 1 to 2, 1 to 5, and 1 to 10, were tried at the different compression ratios.

With the compression ratios of 3.75, 4.38, 4.93 to 1 as shown in Fig. 6, the consumption by weight per horsepower-hour is greater than with gasoline alone but less than with alcohol alone (Note Fig. 6). From these results farm engines and tractors could be economically operated with the mixture when the cost of gasoline is higher than alcohol at certain limits of their ratio of cost.

In the case of the 5.7 to 1 compression ratio, the consumption for the mixture of 1 part gasoline to 2 parts 190 proof alcohol was about equal to that of gasoline alone.

The engine ran smoother with the mixture of alcohol and gasoline than with gasoline alone in all of the above tests. The engine could be started easily with the mixtures of gasoline and alcohol used.

SUMMARY

The general results obtained from these tests may be summarized as follows:

1. Most farm gas engines on the present American market operating with gasoline or kerosene can be run with mixtures of gasoline and alcohol without structural change.
2. Many engines designed for using either gasoline or kerosene can without material alteration be adapted to the mixture of alcohol and kerosene.
3. The total fuel consumption per horsepower-hour, by weight, is less when using a mixture of alcohol and kerosene than when using kerosene alone, except in the case of engines with very low compression ratios.
4. In order to use mixtures of kerosene and alcohol it is necessary to have a carburetor with two fuel needle valves and jets.
5. The mixture of gasoline and 190 proof alcohol, as it forms a miscible mixture to the extent of 1:2 ratio of 70 deg. F. can be readily used in places where alcohol is cheaper fuel than gasoline.
6. The engine started easily with the mixture of gasoline and 190 proof alcohol with a ratio as low as 1 part gasoline to 10 parts alcohol and with a room temperature of about 60 deg. F.
7. To secure economical results it was necessary (a) to keep the circulating water as hot as possible, and (b) to advance ignition timing as the percentage of alcohol in the mixture was increased.
8. The mixture of alcohol to either gasoline and kerosene exhibited less tendency to deposit carbon in the cylinder than kerosene or gasoline.
9. The mixture of alcohol and gasoline or kerosene showed less tendency to dilute the oil than either gasoline or kerosene.
10. The engine ran smoother on the mixtures of alcohol with either kerosene or gasoline than when operated on gasoline or kerosene alone.

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Motorized Teaching Apparatus

By E. G. McKibben[1]

MOTORIZED demonstration apparatus has been a great help in presenting the kinematic and dynamic phases of farm power and machinery instruction in the Division of Agricultural Engineering of the University of California. This has been particularly true in the case of students who are not trained in, and who in many cases lack the capacity for, that quality of abstract thinking required by the conventional analytical methods of presenting theoretical mechanics. Even students well trained in theoretical mechanics, as well as farm machinery service men with a record of many years of successful field experience, have found that a little time spent in studying such apparatus gives them a much clearer conception of the fundamental principles involved.

The teaching equipment shown in Figs. 1 to 3 has enabled the instructor to clear up several disputed points, which have been practically impossible to explain or demonstrate in any other way. The apparatus shown in Fig. 1, which can be conveniently used on a lecture table, enables the instructor to demonstrate the effect of weight distribution, wheelbase length, traction conditions, hitch adjustment and location, and magnitude of drawbar pull upon the stability and tractive and steering ability of a wheel-type tractor.

[1]Assistant professor of agricultural engineering, University of California. Mem. A.S.A.E.

Notation for Fig. 1

a, electric motor
b, reversing switch
c, adjustable drawbar
d, cables supplying tractive reaction
e, blocks for placing under wheels to show the effect of grades, ridges, ditches, and digging in
f, scale for measuring drawbar pull
g, scale for measuring effective weight on front and rear wheels

Notations for Figs. 2 and 3

h, electric motor
i, differential
j, leather-tired wheels
k, adjustment for wheelbase length and front wheel angle
l, adjustment for location of front axle pivot pin
m, brakes on front wheels to demonstrate effect of muddy or loose soil conditions upon steering
n, adjustable drawbar
o, adjustable hitch
p, brakes on trailer wheels for giving a controlled directional drawbar pull
q, markers to record the paths of the tractor and trailer

The apparatus pictured in Figs. 2 and 3 demonstrates the effect of weight distribution, wheelbase length, soil conditions, hitch location and adjustment, and magnitude and relative position of drawbar load upon the steering and turning characteristics of a wheel-type tractor. The size of this equipment is such that it can be satisfactorily used on the lecture room or laboratory floor. (Note scale on Fig. 2.)

This type of apparatus has several advantages over full-size field equipment for the preliminary presentation of the principles involved, although it cannot take the place of an actual field demonstration which should also be given whenever possible. These advantages are:

1. Most of the variables are under better control
2. It is easier to handle students and hold their attention because of the absence of noise and because of the smaller space required
3. The success of the demonstration is independent of weather and field conditions.

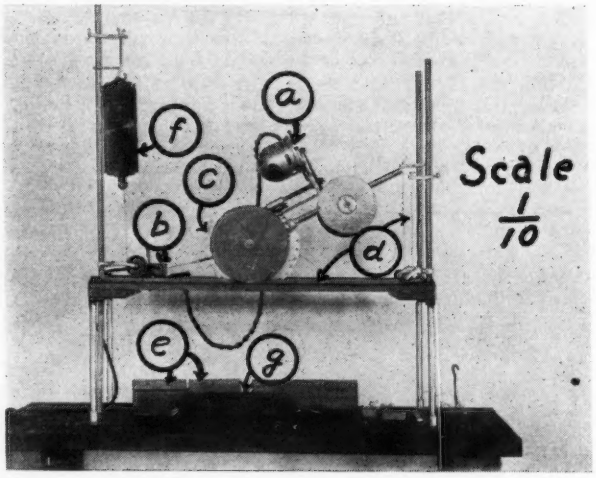
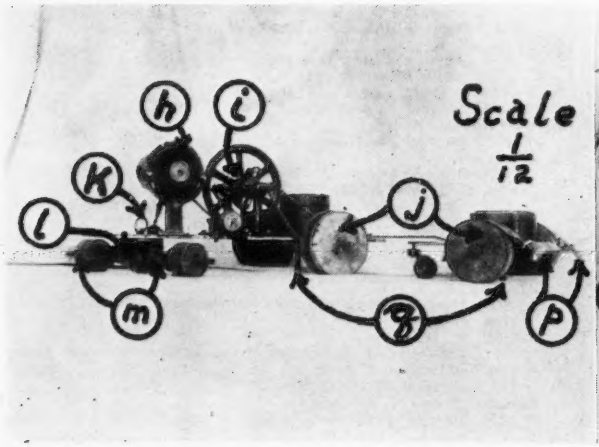


Fig. 1. Apparatus used to demonstrate the effect of weight distribution, wheelbase length, traction conditions, hitch adjustment and location, and magnitude of drawbar pull upon the stability and tractive and steering ability of a wheel-type tractor



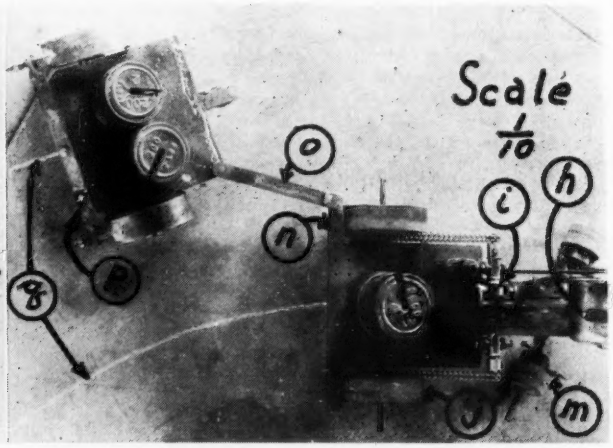


Fig. 2 (left) and Fig. 3 (right). Apparatus used to demonstrate the effect of weight distribution, wheelbase length, soil conditions, hitch location and adjustment, and magnitude and relative position of drawbar load upon the steering and turning characteristics of a wheel-type tractor

Agricultural Engineering Digest

A review of current literature on agricultural engineering by R. W. Trullinger, specialist in agricultural engineering, Office of Experiment Stations, U. S. Department of Agriculture. Requests for copies of publications abstracted should be addressed direct to the publisher.

Irrigation Investigations with Field Crops at Davis and at Delhi, California, 1909-1925, S. H. Beckett and M. R. Huberty (California Station (Davis, Calif.) Bulletin 450 (1928), pp. 24, figs. 9).—This bulletin reports the results of certain irrigation experiments with field crops in the Sacramento and San Joaquin Valleys, California, conducted in cooperation with the U.S.D.A. Bureau of Public Roads and the Division of Engineering and Irrigation, California State Department of Public Works.

At Davis, the average maximum yield and profit were produced on alfalfa with total seasonal applications of 36 acre-inches to the acre. However, 30 acre-inches per acre is considered an economic seasonal application. Total depths of less than 24 in. annually, exclusive of rainfall, were insufficient for satisfactory yields. Depths of 48 in. or more produced smaller yields than did depths of 36 in. Variation in the number of irrigations when a total seasonal depth of 30 in. was applied caused only small differences in yield. The lighter applications, given at more frequent intervals, tended to produce the higher yields, but these did not warrant the extra labor cost.

At Delhi, the maximum yields were produced by 42 acre-inches of water to the acre. In the light soil variations in the number of irrigations did not materially affect the yields, provided the same seasonal depth was applied.

Under field conditions at both Davis and Delhi during the period when the winter rainfall was sufficient to moisten the soil to a depth of at least 6 ft. and where the depth to the underground water table was more than 15 ft., variation in depth of application or in frequency of irrigation did not affect the root distribution of the alfalfa.

Under Sacramento Valley conditions, with a seasonal rainfall of 17 in. or more, normally distributed, the increase in grain yields did not warrant irrigation. In years of deficient rainfall normal yields of grain could be produced with irrigation. Under conditions of extreme rainfall deficiency, two irrigations of from 4 to 6 acre-inches to the acre should be sufficient to produce normal yields. Irrigation of grain land before seeding produced no increase in yields in years of normal rainfall, but did so in years of deficient rainfall.

On medium soil types and in years of normal rainfall in the Sacramento Valley, the net irrigation requirement for full corn and grain sorghum crops should not exceed 12 acre-inches per acre applied in not more than three irrigations. In years of deficient rainfall the net seasonal irrigation requirement for these crops should not exceed 18 acre-inches, applied in not more than four irrigations.

Irrigation of land before seeding is advisable for corn and grain sorghum when rainfall conditions have been such that a proper seed bed can not be prepared, or where there is not sufficient moisture in the surface soil to insure a proper germination of the seed. Under the furrow method of irrigation a normal depth of irrigation is 4 acre-inches per acre for each irrigation.

Resistance to Flow in Floodway of St. Francis River, C. E. Ramser (Engineering News-Record, 100 (1928), No. 14, pp. 541, 542, figs. 4).—In a contribution from the U. S. Department of Agriculture, Bureau of Public Roads, data from measurements of flow through standing timber, made in the St. Francis River floodway in northeastern Arkansas, are reported. The measurements were made at depths of flow ranging from 4.1 to 9.5 ft.

Values determined from the more accurate gaugings showed a continuous decrease in n from 0.152 for the highest stage at an average depth of 9.46 ft. to 0.095 for the lowest stage at an average depth of 4.08 ft. The values determined from the surface gaugings likewise showed a continuous decrease with depth, although they averaged slightly lower than the other group. It is believed that this decrease in n with decrease in stage is due to the fact that fewer branches on the trees were encounterd by the flow at the lower stages. It appears, therefore, that the value of n for high stages in this floodway could be reduced appreciably by cutting all branches that will be submerged at the highest stage of the water.

A Comparison of the Effect of High Temperatures on Concretes of High Alumina and Ordinary Portland Cements, A. L. Miller and H. F. Faulkner (Washington University [Seattle], Engineering Experiment Station Bulletin 43 (1927), pp. 23, figs. 7).—Studies are reported, the results of which are taken to indicate that in structures where the possibility of exposure to greater than ordinary temperatures is remote and the probable period of exposure is short, high alumina cement is a satisfactory substitute for ordinary portland cement if the allowed unit stresses are no greater than those for ordinary portland cement concrete. Where there is a possibility of thorough heating at greater than ordinary temperatures for any considerable period, high alumina cement should not be used for vital structural members until a complete investigation of its qualities under the anticipated conditions is made.

Quality of Water of Pecos River in Texas, W. D. Collins and H. B. Riffenburg (U. S. Geological Survey (Washington, D. C.) Water-Supply Paper 596-D (1927), pp. II + 67-88, pl. 1, figs. 4).—The results of this study indicate that early in the course of the Pecos River it receives large quantities of calcium and sulfate through the solution of gypsum from the soil. Sodium and chloride appear in increasing quantities to the Texas line, but the alkaline earth salts are appreciably in excess of the alkali salts. In Texas the river water carries about equal quantities of alkali salts and alkaline earth salts as far as Barstow. The alkali salts increase from this point on.

Irrigation Experiments at the Colorado Station, A. Kezer (Colorado Station Report (Fort Collins, Colo.) 1927, pp. 13, 14).—It is reported that water colder than the normal when used for the irrigation of wheat in the first spring irrigation apparently had a slight effect. Later the soil apparently became warm enough so that even the coldest water had no retarding effect on the growth.

Municipal and Rural Sanitation, V. M. Ehlers and E. W. Steel (New York and London: McGraw-Hill Book Co., 1927, pp. XI + 448, figs. 119).—This book appears to summarize experience by the Agricultural and Mechanical College of Texas and the State Health Department of Texas. It is pointed out that municipal and rural sanitation now includes in addition to residential sewage disposal and water supplies, such matters as the sanitation of milk and other foods, refuse collection and disposal, the control of mosquitos, flies, and rodents, and plumbing inspection and housing. Chapters are included on communicable diseases, principles of excreta disposal, excreta disposal without water carriage, excreta disposal with water carriage, general characteristics of water, treatment of water, protection of water supplies, refuse collection, refuse disposal, mosquito characteristics, mosquito control methods, organization of antimosquito campaigns, fly control, rodent control, milk sanitation, food sanitation, plumbing, ventilation, light, housing, school sanitation, industrial hygiene, tourist camps, swimming pool sanitation, miscellaneous, disinfection, vital statistics and public health organizations. Appendixes on sanitation measures and considerable tabular data are also included.

Gases from Sewage Sludge Digestion, W. D. Hatfield, G. S. Symons, and R. R. Mills (Industrial and Engineering Chemistry (Washington, D. C.), 20 (1928), No. 2, pp. 174-176, figs. 5).—Studies are reported which showed that the rate and volume of gas production from sludge digestion in Imhoff tanks and the hydrogen sulfide content of the gas are directly proportional to the temperature of digestion. Laboratory data indicate that the maximum gas rate occurs at about 30 deg. C. (86 deg. F.), and that the rate decreases at higher temperatures. A large scale demonstration was given of the advantage of heating sludge digestion chambers to increase the rate of digestion and to increase the sludge capacity through rapid digestion. The chief components of the Imhoff gas are methane 70 per cent, carbon dioxide 20 per cent, and nitrogen 7 per cent.

Termite Pole Damage in California, T. E. Snyder (Electrical West 2, 60 (1928), No. 3, pp. 135-138, figs. 5).—The results of a study conducted by the U.S.D.A. Bureau of Entomology on the damage to rural electric line poles by termites are reported.

It was found that subterranean termites will not attack poles set in a constantly water saturated soil or in soil saturated with alkaline salts. Nonsubterranean termites were found to live more or less indefinitely in old poles stored in pole yards. The injury to poles by subterranean termites is fairly widespread and the most serious. The injury can be prevented by treating the butts of the poles with coal-tar creosote. Damage by nonsubterranean termites is serious but less widespread. Impregnation of the entire pole with coal-tar creosote by a pressure process will prevent such damage but is more costly.

Binding Twine Tests [trans. title], Kloth (Technik Landwirtschaft (Berlin), 8 (1927), Nos. 9, pp. 210-213, figs. 5; 10, pp. 232-234, figs. 9).—Data are presented on tests of the physical properties of binding twine. These indicate that a variability in physical properties of from 10 to 15 per cent will occur in good binding twine.

Dehydration of Fruits and Vegetables in Canada (Canada Department of Agriculture (Ottawa, Can.) Bulletin 90, n. ser. (1927), pp. 29, figs. 13).—This is a summary of four years' work of the dehydration committee of the Canadian Department of Agriculture. The results indicate that it is possible for a dehydrator to make a good product from low grade fresh fruit. Considerable information on the mechanical details and operation of dehydrating plants is presented.

Manual of Forest Engineering and Extraction, J. F. Stewart (London: Chapman & Hall, 1927, pp. XV + 188, pls. [100], figs. [29]).—This manual contains practical information on the subject.

An Investigation of Web Stresses in Reinforced Concrete Beams. —Part II, Restrained Beams, F. E. Richart and L. J. Larson (Illinois University, Engineering Experient Station (Urbana, Ill.) Bulletin 175 (1928), pp. 74, pls. 8, figs. 19).—In further studies on the subject (Agr. Engineer. 9, p. 62), the results of an investigation are reported which embodied tests of 59 restrained reinforced concrete beams of a size comparable to those commonly used in buildings and other structures. The tests were arranged to produce conditions of restraint similar to those found in continuous beams.

In beams with vertical stirrups the greatest stirrup stresses were observed at a distance from the center of the support about equal to the depth of the beam. In beams reinforced with bent up bars the region of maximum web stresses was not very clearly defined, but generally the highest stresses in inclined bars were found when the upper bend of the bar was less than a distance from the support equal to the effective depth of the beam. The greatest stress in an inclined bar was almost invariably found in the part nearest the tension face of the beam.

The stresses in both stirrups and inclined bars were low near the section of contraflexure as compared with stresses measured elsewhere. When properly arranged, bent up bars were found to furnish effective web reinforcement. No slipping of vertical stirrups was observed in any case.

Anchorage of top reinforcing bars by bending them down and providing large hooks in the compression side of the beams generally prevented final bonding failure. End anchorage did not prevent local slipping of bars.

The values of maximum shearing stress developed in restrained beams without web reinforcement varied from 142 to 260 lbs. per sq. in., although in the case of the lower values failure was by tension and bond.

The prevalence of local bond failures at low loads and the resulting formation of cracks, and of the crushing and splintering produced by bends of small radius, were taken to indicate that if high allowable shearing stresses are to be utilized in design, particular attention must be paid to matters of longitudinal tension, bond and bearing stresses.

Poisson's Ratio and the Modulus of Elasticity of Sand-Lime Brick (Journal Franklin Institute (Philadelphia), 205 (1928), No. 2, pp. 251, 252).—In tests of sand-lime brick by the U. S. Bureau of Standards for stress-strain relationships, the value of Poisson's ratio, or the ratio of transverse to longitudinal strain, was found to be one-seventh throughout the range of loading. With the bricks tested on edge the secant modulus of elasticity varied from an average value of about 1,700,000 lbs. per sq. in. at no load to about 1,600,000 lbs. at a stress of 1,000 lbs. per sq. in. The modulus of elasticity in compression was about equal to the modulus in tension.

Manufacture and Uses of Concrete Products and Cast Stone, H. L. Childe (London: Concrete Publications, 1927, 2. ed., pp. X + 248, pls. 5, figs. 160).—This book deals in a practical way with several phases of the manufacture and use of precast concrete products. It contains chapters on materials; proportioning and grading; water content; mixing; consolidation; surface treatment; curing; crazing, efflorescence, and fading of color; manufacture and care of molds; design of molds; plaster, sand, glue and other molds; and roofing tiles.

Investigations on the Refrigeration of Fruits and Vegetables [trans. title], L. R. Plank (Beihefte Ztschr. Gesam. Kalte-Indus., 3 (1927), No. 2, pp. 49, figs. 18).—These experiments, made under German conditions, deal with several different fruits and vegetables. It was found that the most favorable air conditions are individual for different crops. The most favorable temperature in general approaches 0 deg., with a relative humidity of around 90 per cent, together with weak ventilation. It appears that a uniform temperature in the storage is of primary importance. The following table indicates the most favorable conditions of cold storage found for the different crops stored.

CROP	Temperature degrees C	Relative humidity per cent	Air movement	Storage period
Asparagus	+1 to +2	90	weak	3 to 4 weeks
Tomatoes	0 to —1	88 to 90	weak	5 weeks
Green beans	0 to +3	85	weak	3 weeks
Black heart cherries	0 to +1	90	weak	3 weeks
Green strawberries	—1 to +1	90	weak	10 to 14 days
Red gooseberries	0	96	Still	4 weeks
Raspberries	—2 to 0	85 to 90	weak	2 weeks
Green plums	0	95	weak	4 to 5 weeks
Ripe plums	0	95	weak	3 weeks
Early apples	0 to +1	90 to 95	Still or weak	6 to 8 weeks
Grapes	0 to +1	90 to 95	Still or weak	4 weeks
Butter pears	0	90 to 95	Still or weak	Until Christmas
Pears	0	90 to 95	Still or weak	Until middle of January

The Warm-Air Heating Research Residence in Zero Weather, V. S. Day (Illinois University Engineering Experiment Station (Urbana) Circular 15 (1927), pp. 27, figs. 13).—A description is given of the research residence used in the warm-air furnace studies at the University of Illinois, together with some of the results obtained. It was found that a good degree of uniformity of temperature between various rooms can be obtained with a well-designed warm-air heating system. Moderate temperatures at the registers of around 135 deg. F. in the coldest weather were found to be characteristic of a well-designed warm-air heating system. The rapid turnover of the air contents of the house, combined with the admixture of fresh air, constitutes a valuable ventilation feature of warm-air heating. High over-all efficiencies can be obtained with a warm-air heating system. In this case the net loss of heat from the chimney was 11 per cent. Satisfactory relative humidity can also be obtained.

[Agricultural Engineering Studies at the Iowa Station] (Iowa Station (Ames) Report 1927, pp. 9-12).—The progress results of studies on the treatment of silo walls, masonry barn construction, prepared roofing, dairy barns and equipment, air requirements of poultry, the horse as a motor and corn harvesting are presented.

It was found that a cement wash and asphalt paint, when properly applied, are satisfactory in making silo walls impervious and are economical.

In the study of dairy barn floors it was found that concrete and rubber block floors have shown the least wear.

In the study of air requirements of poultry (Agr. Engin., 8, p. 258), the results indicate that air supply in itself is of secondary importance. Temperature, relative humidity, and rates of air movement exercise a much greater influence on health and vitality than does air purity. Furthermore, it has been shown that air purity has little influence upon hatchability of the eggs produced. On the other hand it has been shown that cold and sudden changes in temperature have an almost immediate influence in reduced production.

The Economic Thickness of Building Insulation, M. S. Wunderlich (Journal American Society of Heating and Ventilating Engineers (New York) 34 (1928), No. 3, pp. 189-196, figs. 4).—Data on the economic thickness of insulation of dwellings are presented, indicating that the saving with 1-in. insulation in the ceiling, with coal costing $17.00 per ton, is slightly greater than the saving with 0.5-in. insulation in the side walls. With coal at $9.00 per ton the saving with 1-in. insulation in the ceiling is slightly less than that with the 0.5-in. insulation in the side wall, while with coke at $12.50 per ton the saving is the same.

This is taken to indicate that with a higher fuel cost the insulation in the ceiling should be increased over that indicated as compared with side walls, and that with a lower fuel cost the thickness of the ceiling insulation should approach that of the insulation of the side wall. It follows, therefore, that with the average cost of fuel the ratio of 0.5-in. insulation in the side walls to 1-in. insulation in the ceiling is a well balanced insulated job.

House-Heating (New York: American Gas Association, 1926, 2, ed., pp. 121, figs. 145).—This is the second edition of this book which is a reference on the application of gas to house-heating. It contains chapters on an analysis of the house-heating load, combustion and fuels, the calculation of heat transmission, gas-fired warm air systems, gas-fired steam heating and hot water systems, additional features of heating systems, standard code for testing and rating gas-fired steam boilers, individual room heaters, and service. An appendix of practical data is also included.

Poultry Houses and Fixtures, edited by H. W. Jackson (Dayton, Ohio: Reliance Poultry Journal Publication Co., 1926, 9. ed., pp. 320, figs. 302).—A large amount of information on the planning and construction of poultry houses and fixtures to meet varying conditions is presented.

Book Review

"Harvey Baum—A Study of the Agricultural Revolution," by Edward S. Mead, professor of finance, University of Pennsylvania, and Bernhard Ostrolenk, director of the National Farm School Doylestown, Pennsylvania, is the title of a new book just published by the University of Pennsylvania Press, Philadelphia. This book undertakes to answer these very important and very significant questions: Will Farm Relief relieve the farmer? What is happening to the "average farmer?" What is the paradox of scientific farming? Does every farm require a business manager? How can prices of farm products be raised? In short, what are the many significant aspects in the agricultural revolution taking place in America today?

The book is one of the most comprehensive, most sensible, and most concise yet complete analyses of the agricultural situation that has been written. The book is not a farm manual but a very intelligent discussion of new conditions in agriculture. The authors say that agriculture is entering upon an industrial revolution comparable to that which resulted from the substitution of steam power for man power in industrial uses. They also show the futility of farm relief by political methods and the limitations of cooperative marketing as a means of farm relief. It is a book that should be read by every agricultural engineer interested in the general problem of agriculture. The price of the book is $2.00 postpaid from the publisher.

Who's Who in Agricultural Engineering

A P. Yerkes

W. A. Foster

Theo Brown

A. H. Hoffman

A. P. Yerkes

Arnold Yerkes (Mem. A.S.A.E.)—one of the two representatives of the American Society of Agricultural Engineers contributing to the study of the engineering aspects of agriculture, which is one division of the studies being made by the Committee on Recent Economic Changes in the United States, appointed by former Secertary of Commerce Hoover—is editor of "Tractor Farming," a publication of the International Harvester Company. Previous to taking his present position, he served six years in the Office of Farm Management of the U. S. Department of Agriculture, three years in charge of tractor investigations in the division of farm equipment and the remainder of the time in charge of the division. During the World War he was appointed to assist the farm equipment administrator in the work of alloting and apportioning materials for the manufacture of farm equipment. He is author and joint author of several bulletins of the U. S. Department of Agriculture and of hundreds of articles on farm power and agricultural economics in the farm and implement trade press. He has made an outstanding contribution to agricultural engineering, particularly in connection with the economic aspects. He has served A. S. A. E. as chairman of the Power and Machinery Division, and on a number of committees. He has also contributed several outstanding papers to Society meetings.

W. A. Foster

W. A. Foster (Mem. A.S.A.E.) holds the position of assistant professor of rural architecture at the University of Illinois. He is one of the oustanding advocates in the agricultural engineering profession of a typical American rural architecture and has made some notable contributions to that effort. He is a graduate of Ohio State University with the degree of bachelor of science in education and also with a degree in architectural engineering. For seven years following graduation he was a teacher in industrial and vocational subjects in public schools. Following this he served three years as draftsman in the university architect's office at Ohio State University, and for a time was engaged in architectural practice. Later he was appointed assistant in agricultural engineering of the Iowa Agricultural Experiment Station, which position he held several years devoting special attention to the design of farm structures. He left this position to become head of the department of agricultural engineering at the University of Georgie. He later accepted the position of assistant professor of rural architecture at the University of Illinois, which he now holds. He has presented several notable papers before Society meetings. In 1924-25 he served the Society both in the capacity of second vice-president and chairman of the structures Division.

Theo Brown

Theo Brown (Mem. A.S.A.E.)—chairman of the Standards Committee of the American Society of Agricultural Engineers—is manager of the experimental department of Deere & Company. He is a graduate in engineering of the Worcester Polytechnic Institute. On graduation he entered the employ of the Wasburn Wire Company. A year later he became associated with the Richardson Manufacturing Company of Worcester, Massachusetts, as superintendent, which position he held for nine years. The following five years he was employed as superintendent of The Marseilles Company, of East Moline, Illinois, which company is now a part of Deere & Company. In 1916 he became associated with the experimental department of Deere & Company, of Moline, Illinois, of which department he is now manager. In addition to being prominently identified with and responsible for many recent and important developments in agricultural machinery, he has devoted a great deal of attention to the standardization of farm equipment, particularly intra-company standardization. Besides serving the A.S.A.E. as member and chairman of the Standards Committee, he has also served on other Society committees. He occupies an outstanding position among agricultural engineers associated with the farm equipment industry.

A. H. Hoffman

A. H. Hoffman (Mem. A.S.A.E.)—member of the Council of the American Society of Agricultural Engineers—is research specialist in agricultural engineering at the University of California. He is a graduate of Iowa State College in both electrical and agricultural engineering. For a number of years he was engaged as instructor and later as associate professor of physics and electrical engineering at Iowa State College. For two years he spent three months of each year as lecturer in agricultural engineering at the New Jersey State College and the remainder of his time on experimental work of his own. For one year he was assistant professor of agricultural engineering at the New Mexico State College, which included war training of two detachments of auto mechanics for the U. S. Motor Transport Service. He became associated with the University of California in 1919. He is author of several important technical publications on agricultural engineering. His research work in agricultural engineering at the University of California has been outstanding and has created widespread recognition. In addition to at present being a member of the Council of the A S.A.E., he served as chairman of the Research Committee during 1927-28. He has also served on several other Society committees.

AGRICULTURAL ENGINEERING

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Contributions of interest and value, especially on new developments in the field of agricultural engineering, are invited for publication in this journal. Its columns are open for discussions on all phases of agricultural engineering. Communications on subjects of timely interest to agricultural engineers, or comments on the contents of this journal or the activities of the Society, are also welcome.

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RAYMOND OLNEY, Editor

A Challenge to Engineers

OUR ten million tons of agricultural waste, such as cornstalks, corncobs, grain straws, sugar-cane bagasse, cottonseed and peanut hulls, and other substances produced annually on the farms of the United States formed one of the important topics given serious consideration by chemists at the recent Institute of Chemistry of the American Chemical Society held at Evanston, Illinois. At the conference on researches of immediate urgency in the utilization of agricultural products, it was the concensus that fundamental research in the chemistry of agricultural products is highly desirable for the purpose of obtaining information regarding the properties of chemical compounds which may be produced from raw materials supplied by agriculture. The chemists were of the opinion that such researches are properly the function of the state and federal governments. The following statement of Dr. H. G. Knight, chief of the U.S.D.A. Bureau of Chemistry and Soils, made at this conference, is of particular interest and significance to agricultural engineers:

"In order to make use economically of the great volume of by-products which are now farm wastes, the chemists believe it essential that fundamental research reveal the facts of the chemistry of the carbohydrates, the celluloses, the pentosans, and lignin.

"Investigations leading to the establishment of fermentation industries, the utilization of soybeans for the production of oil, protein and other commercial products, are among the first steps which the chemists recommend as researches of great importance.

"The chemist looks upon the products of agriculture as the raw materials to be worked up by industry to obtain their hidden values, which, in turn, would decrease present wastes and relieve the farmer to some extent by widening the market and stabilizing the demand for his products."

It is the function of the chemist to discover through research the economic uses to which farm by-products, now looked upon for the most part as waste, can be put. When the chemist has done this, it then becomes a function of the agricultural engineer to work out the practical and economic utilization of these wastes for the benefit not only of agriculture, but also of the industries that will convert these wastes into useful products, and of the general public. While considerable progress has already been made in this field, its tremendous possibilities have scarcely been touched. It is one to which the agricultural engineer and the American Society of Agricultural Engineers may well give the most serious consideration and study.

It is indeed a challenge to agricultural engineers!

Taking Advantage of Engineering

IN A discussion between two agricultural engineers, the question came up as to what group of farmers, grouped on the basis of acreage farmed, the agricultural engineers could serve best. One emphasized the need of giving special attention to the problems of the large farm group. The objection was raised that, according to the 1925 census, only 18 per cent of the total of approximately 6,360,000 farms in the United States are to be found in the group having an acreage of 175 acres or over. But, as it was pointed out in answer to this, the significant thing about these figures, assuming that in each group the size of the farm is the average of the limits, is that 67 per cent of the total farm land acreage is to be found in this 18 per cent group. Therefore, from the standpoint of acreage alone this group merits a good share of the attention of agricultural engineers.

As one of these agricultural engineers has pointed out, there are more engineering problems to be solved on the large farms than on the small ones. Agricultural engineers recognize the problems of the small farmer, but it is unquestionably true that the larger farm enterprises are, as a rule, in a better position to take advantage of real engineering development than are the smaller farms. This is particularly true with respect to the use of larger machine units. It was brought out in this discussion that farmers in certain sections of South America appear to have made greater progress than we have in this country in the use of large machine units. Certainly the larger farms are usually better adapted to the more extensive use of these larger, more efficient, more economical units.

The services of agricultural engineers are available to all farmers, small or large, but it would seem that those of the large farm group, for the most part, are in a better position to take advantage of this service, that is, to apply the most recent developments in the engineering of agriculture and agricultural equipment.

Fire Control by Paradox

RECENT discoveries indicate that we still have much to learn about so familiar a phenomenon as fire. By way of example, we found in our own laboratory not long ago that the insulation of the wires used on telephone switchboards could be flameproofed by applying a dilute suspension of selenium to the braided wire. Since selenium is closely related to sulphur and is itself combustible, its effectiveness in flame suppression is extraordinary, and for it no satisfactory explanation has yet been found.

We are now confronted with another paradox in the recent announcement of Thomas and Hochwalt that solutions of such highly oxidizing agents as potassium nitrate (saltpeter), and even the chlorates and perchlorates of potassium, are far more effective in extinguishing fires, and especially oil fires, than water alone. Here, again, the explanation is still lacking, and for want of better understanding the amazing results are attributed to "catalytic" effect.

In the investigation of this effect, compounds of practically every element capable of forming a water-soluble salt were studied, but with one or more minor exceptions, only compounds of the alkali metals appear to possess this "catalytic" effect on combustion. Among these compounds those containing oxygen are the more effective.

Comparative tests demonstrate the startling fact that a solution of such a powerful oxidizing agent as potassium perchlorate is five times as effective as one of potassium chloride and nearly twenty-five times as effective as a solution of common salt.

These discoveries have already received practical application in a new type of portable fire extinguisher.—"Industrial Bulletin" of Arthur D. Little, Inc.

A. S. A. E. and Related Activities

"Power in Agriculture"

THE "Power in Agriculure" session of the summer meeting of the American Society of Mechanical Engineers held at St. Paul-Minnesota, August 27 to 30, was of particular interest and significance to engineers in practically all branches of the profession. The American Society of Agricultural Engineers had previously accepted the invitation of the former society to join with it in presenting a joint program dealing with the general aspects of the application of mechanical power to the agricultural industries. President William Boss, of A.S.A.E., presided at the session, and the papers and discussions were all prepared and presented by members of A.S.A.E.

The session was opened by the presentation of a paper, entitled "Power in Agriculture," by E. A. Stewart, associate professor of agricultural engineering of the University of Minnesota. This paper treated the development of the use of mechanical power in agriculture and outlined the possibilities for the future. The paper was discussed by Arnold P. Yerkes, editor of "Tractor Farming," published by the International Harvester Company. Mr. Yerkes placed special emphasis on the importance of mechanical power as one of the important means at the disposal of the American farmer to meet foreign competition.

"Mechanization of Agriculture" is the title of the paper presented by L. J. Fletcher, agricultural engineer, supervisor of agricultural sales of the Caterpillar Tractor Company, at this session. Mr. Fletcher outlined the variables which influence the design of farm machines, some of the important economic problems involved, an interesting survey of recent developments in the mechanization of agriculture, and present and future trends. His paper was discussed by E. M. Mervine, professor of agricultural engineering, Iowa State College. Mr. Mervine outlined some interesting developments going on in this field.

The purpose of this session primarily was to focus the attention of engineers in the mechanical and other engineering fields on the possibilities of agriculture as a field for engineering application. If one may judge by the meager attendance of engineers, other than agricultural engineers, at this session, it may be said that engineers generally are not awake to the great need and the tremendous field awaiting engineering development in the agricultural industries. It was not anticipated that the session would draw a large attendance of agricultural engineers, principally because of the general nature of the papers presented.

A.S.A.E. Winter Meeting

THE programs for the winter meetings of three technical divisions of the American Society of Agricultural Engineers are taking form rapidly. Preliminary programs of the three meetings will be published in the October issue of AGRICULTURAL ENGINEERING. The divisions that are meeting include the Power and Machinery Division, December 4 and 5; the Structures Division, December 6 and 7; and the Rural Electric Division, December 6. All meetings will be held at the Hotel Sherman, Chicago, and the dates scheduled occur during the week of the International Livestock Exposition.

Relation of Run-Off to Rainfall

AS A part of the symposium on the Mississippi River flood control being conducted by the American Society of Civil Engineers, an investigation of the relation of run-off to rainfall by the present prevailing methods for the Iowa and Des Moines Rivers was made, covering periods prior to and since the construction of extensive drainage works on these watersheds. The purpose of this was to determine the effect, if any, that the drainage operations exerted upon flood flows. The results of these studies were published in the January, 1928, A.S.C.E. Proceedings. A contribution to this symposium by S. L. Moyer, civil engineer, Montevideo, Minnesota, utilizes merely the data given in the original paper and arrives at a very definite conclusion involving a marked indication of effect in a reduction of the flood flow which may reasonably be ascribed to the construction of drainage of the Iowa type.

Inasmuch as this has long been a subject of much controversy and also inasmuch as a number of members of the American Society of Agricultural Engineers will be interested in Mr. Moyer's discussion, he will gladly furnish members of the Society copies of his discussion as long as the supply of copies lasts. Requests for copies of this discussion should be addressed direct to Mr. Moyer.

A.E.C. Has New Assistant Secretary

ANNOUNCEMENT is made by L. W. Wallace, executive secretary of the American Engineering Council, of the appointment of Blake R. Vanleer as assistant secretary effective September 1. Mr. Vanleer is resigning as assistant professor of mechanical engineering at the University of California to accept this appointment. He will devote full time to the position formerly held by A. C. Oliphant.

A.E.S.C. 1928 Year Book

IMPORTANT standardization activities in many American industries during the past twelve months are described in the 1928 yearbook of the American Engineering Standards Committee, just issued. Forty-nine new standards and forty new projects are listed for numerous branches of industry and engineering, including mechanical, civil, electrical, mining, wood, textile, and safety.

The discovery or development of the best processes and practices possible with present-day knowledge, and the extension of these, as standards, to all branches of industry is cited in the yearbook as the object of the standardization movement. The American Engineering Standards Committee has adopted 111 national standards up to the present time and is now working on 164 other standardization projects.

A table of preferred numbers, providing a scientific system for determining the sizes of thousands of common commodities, is one of the new standards which is expected to help lessen the enormous waste in industry by eliminating hundreds of needless sizes. Several national codes for the prevention of dust explosions in terminal grain elevators, flour and feed mills, pulverized coal systems, and other industries where serious dust explosion hazards exist—the cause of an annual loss of hundreds of lives and millions of dollars of property—were adopted during the year. Important progress on other safety codes, especially in mechanical engineering and mining, is also noted.

A standard for mathematical symbols recently adopted as the first of a series of standards for scientific and engineering symbols and abbreviations, is expected to help clear up the difficulties arising from variations in symbols used by different authorities. Various symbols with the same meaning have been used in textbooks, engineering tables and reports. The many experts called together to clear up the resulting confusion were able to agree on a single set of symbols which has now been approved as an American standard.

Copies of the yearbook may be obtained on request to the Committee, 29 West 39th Street, New York, N. Y.

Personals of A.S.A.E. Members

W. J. Gilmore, professor of agricultural engineering and head of the department at Oregon State Agricultural College,

spent the past summer in the employ of the West Coast Lumber Trade Extension Bureau.

Geo. W. Kable has resigned as project director of the Oregon Committee on the Relation of Electricity to Agriculture and agricultural engineer of the Oregon Agricultural Experiment Station to accept an appointment as director of the National Rural Electric Project to be carried on at College Park, Maryland, by the national Committee on the Relation of Electricity to Agriculture. He will take up his new duties November 1.

E. G. McKibben has been appointed associate professor of agricultural engineering at the Iowa State College and assumed his duties August 1. He formerly held a similar position at the University of California.

Russell L. Perry has resigned as instructor in agricultural engineering at the Oregon State Agricultural College to accept a similar position at the University of California, at University Farm, Davis.

F. E. Price, extension specialist in agricultural engineering and soils of the Oregon Agricultural College, has been appointed project director of the Oregon Committee on the Relation of Electricity to Agriculture, succeeding George W. Kable. He will assume his new duties September 15.

New A.S.A.E. Members

Ernest L. Guttersen, general manager, North American Oil Co., Ltd., Winnipeg, Manitoba, Canada.

Maxie E. Landry, rural electrical power promoter, Wagner Electric Corporation, Kansas City, Mo.

David M. Morris, designer, International Harvester Co., Ltd., Hamilton, Ontario, Canada.

Applicants for Membership

The following is a list of applicants for membership in the American Society of Agricultural Engineers received since the publication of the August issue of AGRICULTURAL ENGINEERING. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

M. A. Sharp, assistant professor of agricultural engineering, Iowa State College, Ames, Iowa.

Charles P. Wagner, rural service engineer, Northern States Power Co., Minneapolis, Minn.

Transfer of Grade

Fred C. Fenton, professor of agricultural engineering, Kansas State Agricultural College, Manhattan, Kans. (Associate Member to Member.)

Harold C. Jackson, Jr., training for salesman, John Deere Plow Co., Moline, Ill. (Student to Junior Member.)

Frank D. L. Jones, experimental engineer, Dain Mfg. Co., Ottumwa, Iowa. (Junior to Associate Member.)

Employment Bulletin

This service, conducted by the American Society of Agricultural Engineers, appears regularly in each issue of AGRICULTURAL ENGINEERING. Members of the Society in good standing will be listed in the published notices of the "Men Available" section. Nonmembers as well as members, are privileged to use the "Positions Open" section. Copy for notices should be in the Secretary's hands by the 20th of the month preceding date of issue. The form of notice should be such that the initial words indicate the classification. No charge will be made for this service.

Men Available

AGRICULTURAL ENGINEER available. Seventeen years experience in the designing and manufacture of farm tractors, motor trucks, harvesting machines, and earth-working tools. Sales experience in United States, Canada, England, France, and Italy. Write for interview. MA-132.

EDITOR AND WRITER with ten years experience in farm mechanical equipment, from both trade journal and farm paper angles, specializing on promotion and technique of power farming. Qualified for publication, house organ, advertising literature, or sales promotion work involving technical accuracy and popular appeal. Farm background, college training, instructional experience. W. B. Jones, St. Joseph, Mich.

AGRICULTURAL ENGINEER desires position as general manager of large agricultural concern where initiative, ability and resourcefulness are required. Has knowledge of legal procedure and finance, has handled agricultural propositions employing three thousand men, speaks Spanish, recently carried out reorganization in Latin America for one of the largest banks in this country. Can furnish credentials as to character, integrity and sobriety. 40 years of age, excellent health, American native born, protestant, married. Will go anywhere but prefers continental U.S.A. MA-148.

Positions Open

AGRICULTURAL ENGINEER with college training and practical experience with tillage tools and seeding machinery wanted by a farm machinery manufacturer in the Middle West. Must be skilled draftsman and have designing ability. PO-132.

AGRICULTURAL ENGINEER wanted for position as teacher of farm machinery in a southern agricultural and mechanical college. Salary about $3000. Position has excellent opportunities. PO-135.

SERVICE MANAGER to organize field service, prepare instruction books, and repair parts list is wanted by power farming machinery manufacturer. Must be loyal, aggressive, and able to handle service men, dealers, and customers. Give full details of training, experience, references, etc., in first letter. PO-136.

MECHANICAL ENGINEER wanted by power harvesting machinery company in the middle west. Must be aggressive, loyal, ambitious, and capable of handling drafting room. Also must be able to cooperate with manufacturing department. State training and experience in first letter. PO-137.

AGRICULTURAL ENGINEER wanted by a steel products company to assist in the development of their line of sheet metal and steel articles for farm use. Must have good fundamental technical training and an understanding of agricultural practice, especially in the Northwest states. Duties will include some field work and investigation. The company has been established many years, is well rated and has excellent marketing connections. PO-138.

AGRICULTURAL ENGINEER wanted to do teaching and experiment station work in the agricultural engineering department of the Montana Agricultural Experiment Station and State College. The specific work will be in irrigation and drainage. Write H. E. Murdock, Bozeman, Montana.

MANAGER AND EXECUTIVE wanted to undertake the direction and execution of an agricultural development of 6,000 acres of land in Florida. Position calls for a man of wide experience in production of products which are possible to Florida and one whose practical experience is backed up by a reasonable amount of scientific knowledge. He must be a man whose reliability and integrity are beyond question and whose executive ability is of a high order. He must further have the faculty of doing things at the least possible cost. PO-139.

DESIGNERS AND DRAFTSMEN wanted. One of the leading farm equipment manufacturers is increasing its engineering personnel and desires to secure the services of two or possibly three designers and draftsmen, preferably those who had had tractor, implement, or allied experience. PO-140.

PRACTICAL FARMER wanted to team up his experience and labor with the land and operating capital of a farm owner in Guatemala. Prefer married man about thirty years of age, one who understands the raising of corn, wheat, garden truck, etc., and who also understands tractors and other farm machinery and can utilize modern equipment in a modern way. Traveling expenses can be advanced and ample farm operating funds provided. Profits split fifty-fifty. Write fully giving age, education, experience; send photograph. PO-141.

MECHANICAL FIELD REPRESENTATIVE for sales department wanted by a leading manufacturer of farm equipment. Will have charge of field organization throughout the company's branch house territory. Must possess qualifications to deal with salesmen as well having engineering ability. PO-142.

AGRICULTURAL ENGINEER wanted to assist in teaching general agricultural engineering subjects, preferably one qualified along farm machinery lines. Should be qualified to take freshmen in a three credit course, stressing mechanics, electricity, hydraulics, etc., in as practical a way as possible. Minimum salary, $2400. This can be increased if right man is located. Address W. J. Gilmore, professor of farm mechanics, Oregon State Agricultural College, Corvallis.

U. S. CIVIL SERVICE OPENING

The U. S. Civil Service Commission announces open competitive examinations for associate agricultural engineers ($3,200—3,700 a year) and for assistant agricultural engineers ($2,600—3,100 a year). The duties of appointees will be in connection with original research and investigation for design and construction in agricultural engineering. Vacancies exist at present at Toledo, Ohio. The work at this station is principally in connection with the design of machinery for combating the spread of the European corn borer. Applicants should secure and execute form 2600 and have it on file with the Civil Service Commission at Washington not later than September 19, 1928.